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GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
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Participant Handbook

Sector
Telecom

Sub-Sector
Passive Infrastructure

Occupation
Operation & Maintenance – Passive Infrastructure

Reference ID : **TEL/Q6401, Version 4.0**

NSQF Level 4

Optical Fiber Technician

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Shri Narendra Modi
Prime Minister of India

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TELECOM SECTOR SKILL COUNCIL

for

SKILLING CONTENT : PARTICIPANT HANDBOOK

Complying to National Occupational Standards of
Job Role / Qualification Pack : 'Optical Fiber Technician'
QP No. **'TEL/Q6401, NSQF Level 4'**

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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 Optical Fiber Technician. Optical Fiber Technician 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 Optical Fiber Cable (OFC) as per the route plan.

This Participant Handbook is based on Optical Fiber Technician Qualification Pack (TEL/Q6401) & includes the following National Occupational Standards (NOSs)

1. Co-ordinate Installation & Commission of Optical fiber cables (OFC) (TEL/N4137)
2. Undertake Condition based Maintenance & Planned repair activities (TEL/N6403)
3. Perform Corrective Maintenance/Restoration of Optical Fiber Faults (TEL/N6404)
4. Organise Work and Resources as per Safety Standards (TEL/N9101)
5. Interact Effectively with Team Members and Customers (TEL/N9102)

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


Learning Outcomes


Unit Objectives


Tips


Steps


Notes


Exercise

Table of Contents

Skill India
कौशल भारत-कुशल भारत

सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
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Roles and Responsibilities of Optical Fiber Technician

UNIT 1.1 - Brief overview of Telecom & Fiber Optics

Key learning Outcomes

At the end of this module, you will be able to understand:

1. Broadband industry overview
2. Optical Fiber Technician role and responsibility
3. PSTN (public switch telephone network) operations
4. Overview of Transmission media
5. Important Terminologies used in Fiber Optic

UNIT 1.1:Brief overview of Telecom & Fiber Optics

Unit Objectives

At the end of this unit, you will be able to understand:

1. Explain the size and scope of the Telecom industry and its subsectors
2. Fiber technician role & responsibility
3. Identify various employment opportunities for an Optical Fiber Technician

1.1.1 Broadband Industry

In the present Global context, telecommunication is playing a key role on changing the whole dimension and taking the progress to next level. Telecommunication is not only influencing urban scenarios but also changing the economy and means operations at rural parts of the country. Indian telecom is bringing considerable revenue by telecom services increasing its customer range in the country across. The Government of India has recognized this fact and has taken various measures over the years to stabilize the telecom sector. Indian telecom sector stands in 2nd position after China wireless market.

A stable transmission and transport systems strengthen the mobile network which further helps in providing the best services to users. To bring the best result system should possess strong back haul network built. Indian dream project digital India led to construct digital back bones across the country to fulfill the vision of end reachability across PAN INDIA. Indian Government initiated Bharath net – NOFN (National Optical Fiber Network) to build data coverage reach till last milestones (connecting remote to remote villages via internet). Under this project fiber has been laid across 2.5 lakh Gram panchayat with the ideal plan of 100 MBPS broadband coverage. The

- Project initiated by Indian Government made phase mode approaches for implementations, over the time tentatively with deadline of 2019, it intends to connect all villages across the India together. In the first phase about one lakh gram panchayats with broadband connectivity by laying underground optic fibre cable (OFC) lines which was completed in Dec 2017.
- The second phase aimed to provide connectivity to all 2,50,500-gram panchayats in the country using an optimal mix of underground fiber, fiber over power lines, radio and satellite media. It was planned to be completed by March 2019.
- In the third phase which is planned to provide ring topology network with state-of-art fiber optic, future-proof network. The work commenced in 2019 and is expected to complete by 2023.

1.1.2 Size & Scope of Telecom industry and its Subsectors

The **telecommunications industry** is made up of businesses that enable global communication, whether it be via the phone or the Internet, over airwaves or cables, via wires or wirelessly. These businesses built the cables, via wires or wirelessly. These businesses built the network that enables the transmission of data in the form of text, voice, audio, or video throughout the globe.

Internet service providers, satellite companies, cable companies, and telephone operators are the biggest businesses in the industry.

Fig. 1.1.2

Infrastructure, Equipment, Mobile Virtual Network Operators (MNVO), White Space Spectrum, 5G, Telephone service providers, and Broadband are the subsectors that make up the telecommunications sector.

The Indian telecom tower market has expanded dramatically by 65% during the last seven years. In 2021, there will be 660,000 mobile towers, up from 400,000 in 2014. Similar to this, there will be 2.3 million mobile base transceiver stations in use by 2021, up quickly by 187 percent from 800,000 in 2014.

Additionally, it is predicted that 5G technology will boost the Indian economy by $450 billion between 2023 and 2040. The IMT/5G spectrum auction is now underway.

According to the GSMA, India will have almost 1 billion installed smartphones by 2025 and 920 million unique mobile customers, including 88 million 5G connections. This will make India the second-largest smartphone market in the world.

Nearly the past ten years, India has added over 500 million additional smartphone users. By 2026, there will be 850 million smartphone users worldwide, or around 55% of the population.

By December 2022, the DoT wants to have 30 lakh km of fiber-optic cable installed, average internet speeds of 25 mbps, and 100 percent broadband access in all of the country's villages. By December 2024, it is looking at 70% fiberisation of towers, average broadband speeds of 50 Mbps and 50 lakh kms of optic fiber rollouts at a pan-India level.

The transition to digital learning and remote working:

Due to the COVID-19 pandemic's impacts, digital learning and remote working have grown in popularity in recent months. Telcos have played and will continue to play a part in the acceleration of the shift from learning and working in physical places to online due to the pandemic. Reliable and secure connectivity as well as data management are required for online learning and remote working to function properly. Numerous Telcos have had to negotiate this and will continue to do so.

The provision of the same level of accessibility and connectivity to those in remote places is another factor that must be taken into account when examining this trend and potential development chances.

Infrastructure sharing:

Telecom service providers can share infrastructure in many ways, depending on telecom regulatory and legislation. At a cell site, **passive infrastructure** sharing involves sharing non-electrical infrastructure. Globally, the telecom industry is seeing a rise in the use of passive infrastructure

- **Site** sharing includes antennas and mast; this may also hold Base transceiver station (BTS), Node B in UMTS context and common equipment such as Antenna system, masts, cables, ducts, filters, power source and shelter.
- Sharing a mast is called **mast** sharing.
- **Antenna** sharing shares an antenna and all related connections (coupler, feeder cable), in addition to sharing electronic infrastructure is **active sharing.**

The notion of **spectrum sharing**, also known as frequency sharing, is based on a lease model and is frequently referred to as "spectrum trading." An operator may agree to a commercial lease with another operator for a portion of its spectrum. Although MVNOs and this technique are present in the US, Europe, Singapore, and Australia.

- **Base station** sharing is prospective, and each operator retains control over logical Node B, which enables it to operate the carrier's assigned frequencies independently of the partner operator. It also retains control over active base station equipment, such as the TRXs that regulate reception and transmission over radio channels. Here, the core network and radio network controller are separate.
- **Radio Network Controller (RNC)** sharing entails keeping logical control over each operator's RNC in isolation.
- Sharing **switches (MSC) and routers (SGSN)** on the operator's fixed network is referred to as backbone sharing.
- **Network sharing** in which a network infrastructure is specifically built with resource sharing in mind. For instance, a joint venture between Telenor Sweden (formerly Vodafone Sweden) and HI3G created a shared network that covers 70% of Sweden (Hutcheson Investor). When a user is inside one of the major cities, his calls are routed through Telenor's or HI3native G's network infrastructure, while when he is outside of the cities, his calls wander into 3GIS's common network.
- **Geographical splitting** A FTTH(fiber to the home) network's design is heavily influenced by geography, particularly in how it affects subscriber density. Population-dense areas need less cable and typically more fiber splitters, while suburban areas with lower densities frequently use cascaded splitters to serve fewer subscribers per splitter. In rural areas, long cable runs are frequently necessary, and the choice of whether to connect the subscriber using fiber or wireless must be made. Rural networks feature a variety of alternatives, including remote OLTs and splitter

1.1.3 Role and Responsibilities of an Optical Fiber Technician

Installing and maintaining fiber optic cable networks is the responsibility of **fiber optic technicians**. They are tasked with anything from putting together little bundles of fiber to pulling cables through underground conduits.

Numerous industries, including telecommunications, industrial automation, medical imaging, and entertainment, use fiber optic technology. In the creation and application of these technologies, fiber optic technicians are crucial.

Fiber optic technicians have a wide range of responsibilities, which can include:

- Examining, evaluating, and maintaining machinery utilized in communication networks
- Setting up new fiber optic networks and fixing current ones as necessary
- Setting up and maintaining repeaters, switches, and other networking hardware used in telecommunications networks
- Setting up new infrastructure or upgrading current infrastructure to take advantage of technical developments in the telecommunications sector
- Setting up cable television equipment, including amplifiers, filters, splitters, and converters, and testing the reception's signal strength
- Setting up fiber optic hardware, including splicing machines, test equipment, and cable termination devices
- Installing fiber optic cables in aerial or conduit spaces, such as between buildings or atop telephone poles
- Troubleshooting fiber optic networks in order to find issues and offer solutions
- Finding subsurface utilities including gas, water, and electrical lines before starting construction

1.1.4 Skills Required to be successful

Fiber Optic Technician Skills: Fiber optic technicians need the following skills in order to be successful:

- Technical skills: A technician employs their technical skills and knowledge to carry out tasks. To install and fix fiber optic cables, splice fiber optic cables, troubleshoot fiber optic cable issues, and perform other jobs, fiber optic technicians employ their technical expertise.

- Communication skills: Since fiber optic technicians frequently operate in teams, they must be able to describe their job to others in a clear and straightforward manner. They must be able to explain technological processes and procedures to clients because they work with them frequently.

- Problem-solving abilities: Fiber optic technicians employ their problem-solving abilities to diagnose equipment problems, pinpoint the source of network outages, and fix damaged cables. These abilities are also used to choose the best tools and equipment to employ and to choose the most effective manner to execute jobs.
- Attention to detail: To make sure they are installing the equipment correctly; fiber optic specialists need to pay close attention to every detail. Before they depart a project site, they must also make sure the equipment is in good working order. This is crucial to guarantee the client is happy with the job and to stop any potential problems in the future.
- Teamwork abilities: Being a part of a team can help you learn more about your career and advance your talents. By participating in a club or volunteer organization at your school, you can develop your teamwork skills. Working together with your co-workers to complete tasks and solve difficulties is another way to learn

1.1.5 Fiber Optic Infrastructure growth

Fiber optic infrastructure expansion is a trend that is becoming more and more popular all over the world. The demand for experienced professionals to install and maintain these systems will increase as more homes and businesses adopt fiber optic technology Because they possess the knowledge necessary to install, test, and troubleshoot fiber optic systems, fiber optic technicians are in high demand. There will be a rising need for these specialists due to the fiber optic infrastructure's continuing expansion

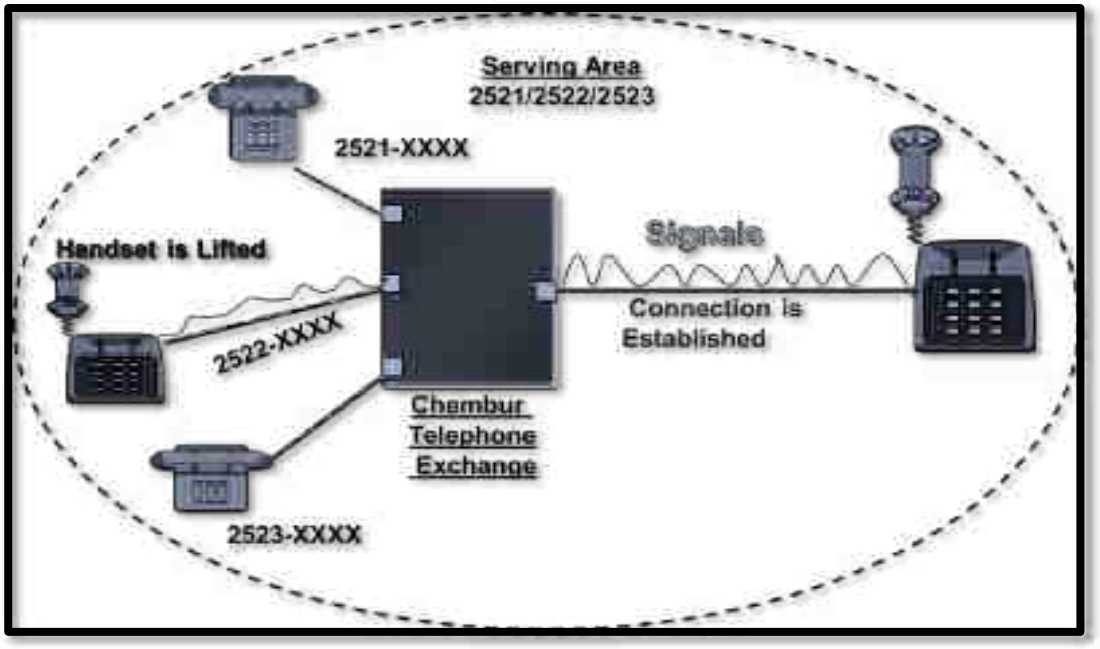
Fig1.1.5 Fiber Optics

1.1.6 Public Switched Telephone Network (PSTN)

PSTN (Public Switched Telephone Network): Standard telephone service, e.g. BSNL, MTNL, etc. Through a 'SWITCH'

PSTN – uses end to end closed connectivity, it adopts Switch concept in implementing the network. Every user will be given with a closed-circuit line. Circuit is connection of devices with wired cables which could be controlled to opens and closes. PSTN is fully wired network, every end user is connected to main controlling station (called exchange). These exchanges further inter connected with rest of the surrounding exchanges with wires/cables, connectivity continues till the national gateway which continues to build connectivity with surrounding countries. The connectivity may be further enriching with satellite and microwave connectivity.

When a customer picks up the handset of the landline from the cradle his/her connection at the telephone exchange is ready to receive the signals which he dials from his telephone in the form of the number to which he / she wants to speak. Through his connection the exchange starts sending signal to mobile or landline phone (depending on the number he is dialing). As the person picks up the phone the circuit is complete and they can now start talking to each other.



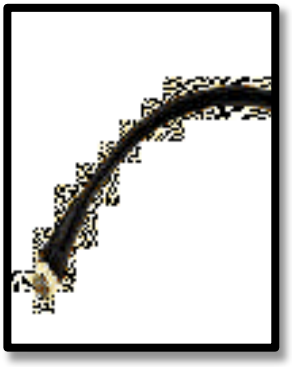
1.1.2 : Public switched telephone network

1.1.1 Transmission Media

Cable type in which the two conductors are twisted and same is used in circuit connections. This type of cables is termed as twisted pair. The twist made from the cable will avoid the external charge influence.

1.1.3 (a): Twisted copper wire

Copper being the inner core of twisted wire cable protected with protective material. There are plenty of coaxial cables in market comes out with protective jacket and multiple layered protective sheets.



1.1.4 (b): Coaxial cable

1.1.4 Transmission Media (Contd.)

Optical fiber cable could be used in a fashion of single modal or multi modal holding single fiber or multiple fibers in the cable. The fibers are used based on the application and the best practices followed in the system.

1.1.4 (c): Optical fiber cable

Microwave is part of electromagnetic spectrum used in parallel with Radio frequency range of frequencies. As microwaves are best resulted in long distance and line of sight travel, it is used effective in RADAR operations. Satellite are the system device setups hosted from earth to space, located at different orbit of earth where the system made operational and it is away from earth gravitation pull.

1.1.4 (d): Microwave

These devices work on microwave frequencies and connect to the stations on earth. Satellite systems serves for weather forecasting, television, communications, military and many other purposes.

1.1.4 (e): Satellite

1.1.5 Important Terminologies

Terminology	Definition
Signal	Frequency representation which conveys information could be a form of simple data or in complex message format.
Signaling	Signaling is the process of connecting source and destination by doing authentication of the service and users and authorizing the session
Frequency	The number of times in a second an electric signal or electromagnetic wave, completes a cycle.
Network	Group of systems interconnected in a fashion where they could share, exchange data, and communicate the necessary.
Mode	Fashion/ way of propagation in a media, in specific to Fiber cable mode is the light patterns which are made to travel across. .
Multimode fiber	Kind of mode in which more than one light signal can travel across is called as multimodal fiber. It naturally little bigger than single mode fiber. (Almost always 50 or 62.5 microns - a micron is one millionth of a meter).
Single mode fiber	Fiber which allows single Light wave to travel across is termed as Single mode fiber. It has smaller core compare to multimodal fibers (about 8-9 microns). Single mode is mostly preferred for telecommunication services like telephony, fiber to the home and CATV.
Fiber ID	Based on the fiber inner and outer core construction Fiber ID tagged for identification. Core and cladding diameters are expressed in microns; most multimode and single mode fibers have an outside diameter of 125 microns. Fiber IDs are internationally standardized with specifications that include all characteristics.
Plastic optical fibers (POF)	One type of multimodal fibers. Normally preferred for short distance for networks which run effectively with low speed.
Cable	Cables come in various colors and sizes. These protect the fiber from weather, provides protection from stress. Cables are manufactured based on the number of fibers to be accommodated. There are many types of cables few in list are tight buffer (with hard plastic coating on fiber preferred for mainly indoors), loose-tube, (light coating on fiber), ribbon (fibers made ribbons).

1.1.2 Important Terminologies (Contd.)

Terminology	Definitions
Jacket	The outermost cover on the cable is termed as jacket. These jackets provide additional safety to the cables.
Strength members	The supportive element used for safety and operations
Armor	Armor Discourages rodents from chewing through it.
Connector	Device used for connecting fibers. The connectors could be kept in system and could be disconnected based on requirement.
Ferrule	A tube which holds a fiber for alignment, usually part of a connector. / No need to change.
Splice	Joining fibers /broken fibers is carried out with a tool termed as splicer and process called as splicing. This joint (splice) between two fibers made will be permanent.
Hardware	Terminations and splices require hardware for protection and management patch panels, splice closures, etc.
Attenuation	Loss in the power while signal travels across is termed as attenuation. Mostly expressed in decibels (dB). For fibers, considerable is attenuation coefficient or attenuation per unit length with unit of dB/km.
Bandwidth	Group of frequencies could be termed as Bandwidth. The difference between the frequencies ranges transmitted is considered as Delta Frequency in turn called as bandwidth.
Decibels (dB)	A unit of measurement of optical power which indicates relative power. A -10 dB means a reduction in power by 10 times, -20 dB means another 10 time or 100 times overall, -30 mean another 10 times or 1000 times overall, & so on
dB	Optical power measurement is done by dB (decibel). Decibel helps in understanding the power variation dB representation, -10 dB refers to a reduction of power by 10 times, -20 dB means further reduction 10 times or 100 times overall, and so on.
dBm	absolute Optical power measurement referring to 1 milli watt
Optical Loss	The amount of optical power lost as light is transmitted through fiber, splices, couplers, etc., expressed in "dB"
Switch	A mechanical or electronic device that opens or closes circuits completes or breaks an electrical path or selects paths or circuits.
Multiplexing	Process of missing multiple signals before transmitting over media.

1.1.5 Important Terminologies (Contd.)

Terminology	Definition
Optical Power	Capacity of optical signal strength represented in terms of power, measured in dBm/decibels.
Scattering	Dispersion of light ray due to obstacles. Tag name given for the light ray changing the path of travel and splitting energy into multiple angles this will cause majority of loss in optical fibers and is used to make measurements by an OTDR.
Wavelength	Wavelength a term for the color of light, usually expressed in nanometers (nm) or microns (m). Fiber is mostly used in the infrared region where the light is invisible to the human eye. Most fiber specifications (attenuation, dispersion) are dependent on wavelength.
Dispersion	Pulse spreading caused by modes in multimode fiber (modal dispersion), the difference in speed of light of different wavelengths (CD or chromatic dispersion in multimode or single mode fiber) and polarization (PMD or polarization mode dispersion in single mode)
PSTN (Public Switched Telephone Network)	Traditional wired phone service. It refers to the standard telephone service, e.g., BSNL.
BTS (Base Transceiver Station)	It is a wireless interface with a mobile handset in mobile communication. It has an antenna mounted on a tower and a trans-receiver
BSC (Base Station Controller)	BTS are administered by a BSC Signaling.
MSC (Mobile Switching Center)	It is the hub of the mobile communication network. It connects mobile stations to PSTN.
Roaming	Realization of all frequency ranges in sequential manner.
Spectrum	Device used for the TRX operations from user end.
Telephony	Word used to describe the science of transmitting voice over a telecommunications network.
Modem	A device that both modulates and demodulates signals.

1.1.5 Important Terminologies (Contd.)

Terminology	Definition
NLD	National Long-Distance Telephony – pertains to calls outside the local area, to any place in India.
ILD	International Long-Distance Telephony – outside India.
SDCA	Short Distance Charging Area – There are total of 2647 SDCA in India, each having a unique STD code.
LDCA	Long Distance Charging Area. A few SDCAs make a LDCA. A call beyond 50 km distance is considered as a long-distance call.
Service Plan	The plan under which it operate publicize the service lists to user is termed as service plan. This plan may have altered over time.
Tariff	Services offered to users are categorized based on the subscription and categories known as tariff.

1.1.5 : Optical fiber technology has tremendous potential

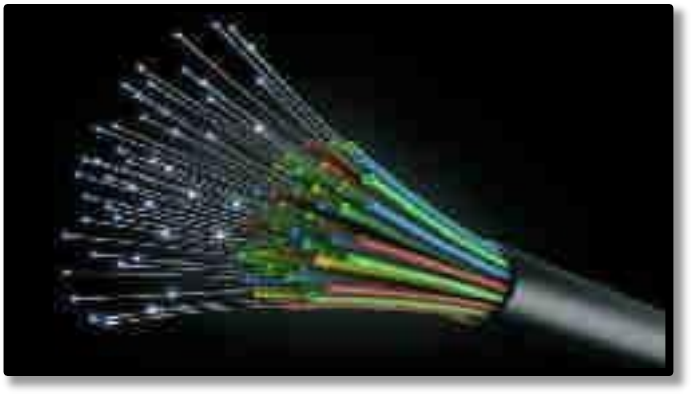
1.1.6 Optical Fiber Technology

Optical transmissions over the fiber cables need immense strengthen technology associated. Optical cables inner core glass is made in a way to propagate complete ray travelling by giving zero resistance and losses. To achieve connectivity over long distance optical medium proven to be the best even though it is laying and maintenance takes more economy. Unlike in copper cable electrical signal converted into light and it is transmitted over fiber cables. It began about 40 years ago in the R&D labs (Corning, Bell Labs, ITT UK, etc.) and was first installed commercially in Dorset, England by STC and Chicago, IL, USA in 1976 by AT&T. By the early 1980s, fiber telecommunications networks connected the major cities on each coast. By the mid-80s, fiber was replacing all the telecom-copper, microwave and satellite links. In the 90s, transoceanic fiber optic cables replaced sate llites between most continents.

Over the period fiber optics took over the entire major service provider favorite as its effectiveness ruled out the cost. DTH and CATV are few services mostly relied on fiber network. Adding on the Research prove that the network will be the reliable to provide Internet services, mobile services network development.

Slowly the fiber placed in the small networks and then tried with LAN, WAN, MAN, and most of implantations is taking place with fiber network in today's data . As the cables could be routed fascinatingly without disturbing the infra, more company's showed interest in having fiber network. Fiber is effective in huge data transfer and connectivity with reliability. Fiber is implemented in most Multinational companies with fiber LANs backbones, connections to systems for employees or design workstations with many wireless AP (access point).

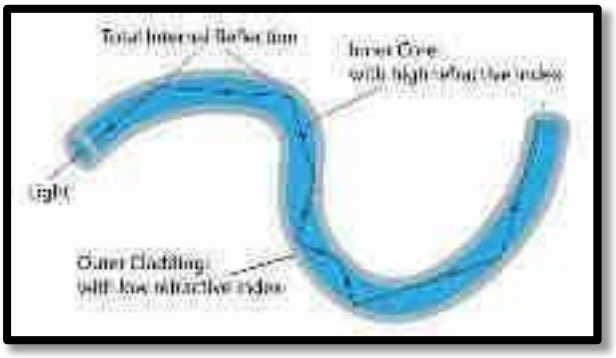
Some more applications for consideration are: mobile - cell network connections, Ship & aircraft, automation and automobile connecting lines, security like CCTV, & digital stereos for consumers. Fiber optics users in current time zones are systems who use it for connecting social blocks like Educational institutes, stores/ departments, transport& traffic lights, security add on like CCTV surveillance systems. Fiber to home is another upcoming big business which provides the best connections to their users. Optical fiber is either predominant medium or choice made logically for most of communication system. With reduced Costs fiber to the home is most likely accepted by user ends, the fantasy come true for users as fiber to home provides all means of data and services which other medium fails to provide.



1.1.6 (a): An optical fiber

1.1.6 Optical Fiber Technology (Contd.)

Fiber optics would be used as a channel for communication & networking as it is easy and flexible. Plastic or glass manufactures fibers, it is s used in long-distance applications of telecom. Optical fibers mostly prefer glass inner core medium than plastic as glass provide low absorption. Optical fiber principally uses total internal reflection phenomenon for the light transmission within the material. Due to total internal reflection angle Eliminates distortion, leakage, reflection, signal crosstalk between fibers within the cable and allows the cable routing (supporting twists and turns). Infrared Light is mostly used for communication in case of telecom applications, as wavelengths proven best for the case (minimum absorption with fiber).



1.1.6 (b): Total internal reflection

Infrared Light is mostly used for communication in case of telecom applications, as wavelengths proven best for the case (minimum absorption with fiber). Fibers could be practically implemented in terms of single fiber, pairs of fibers for every carrier connection. Single mode and multimodal fibers are used based on the distance and application. Coupling/splitting devices enable the system to lay the cable for distances and overcoming geographical challenges. Waveguides normally could support multiple modes of transmission. For long distance communications, single mode fiber is widely preferred., as propagation mode is singular it provides effectiveness with minimum distortions. In fibers supporting multi-mode, transmission on multiple time on multiple timings transmitted in the different modes arrives at different times, resulting in dispersion of signal.

Between signal generations single mode fiber optic cables sustain transmission distances of 80 to 140 km approx. distance of 300 to 500 meters are recorded in case of multi -mode. Single mode equipment's are comparatively little more costly than multi -modal equipment. Fibers deployed in telecommunications normally hold diameter of 125 µm. The core transmission of single mode fibers most commonly support diameter of 9 µm. Multi-mode cores are available with 50 µm or 62.5 µm diameters. Single mode fiber offers low loss, high linearity and dispersion, with a estimate data rates of up to 40 Gbit/s on a single wavelength. WDM - Wavelength division multiplexing could be used further to allow many wavelengths to be used at once on a single fiber. Estimated that single fiber provides an aggregate bandwidth in terabits per second.

Click/Scan the QR code to know what is Fiber Optic Cable?

1.1.3 Optical Fiber Technology (Contd.)

Today's cables of optical fiber could provide a range of capacity, example: thousand fibers in a single cable. Optical fiber performance fulfils the needs of the required bandwidth. Unutilized end to end powerful bandwidths do not convert to operating benefits, and it is calculated that not more than 1% of the optical fiber laid under soil recent years is lit. Presently manufactured cable s hold wide variety of sheathings, Armor, prepared for applications. Some application to list is: direct burial in trenches, installation in conduit, lashing to aerial telephone poles, submarine installation, or insertion in paved streets.

Presently Improvements in fiber technology have minimized losses to an extent that no amplification of the optical signal is required for a considerable 100km. it has greatly cut down the cost of optical networking, especially in undersea spans where the cost reliability of amplifiers is one of the key factors shaping system performance of the whole. In the previous few years several manufacturers of submarine cable line terminal equipment have introduced improvement that promise to quadruple the capacity of older submarine systems installed in the early to mid-1990s.

Factors due to which optical fiber are used are advantages available which are not present in metallic conductor/ microwaves. Important use of optical fiber is it can transport more information longer distances in less time than compare to other communications medium. Add on, it is unchanged by the EM (Electromagnetic) interference of radiation, due to which data could be transmitted with less noise & error. There are also couples of applications in fiber optics that are simply not possible with metallic conductors. It holds sensors/scientific applications, medical/surgical applications, industrial applications, subject illumination & image transport. Many fiber optics are made of glass, even though few made of plastic.

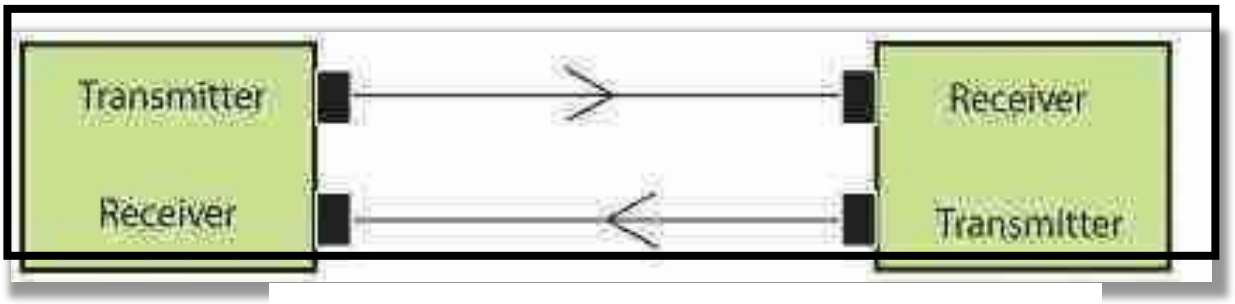
Mechanical protection is a concern and hence optical fibers are housed inside cables. Specific cables types and configurations are practiced for specific cases as: indoor, outdoor, in the ground, underwater, in ocean & overhead.

1.1.6 (c): current global undersea optical fiber network

1.1.6 Optical Fiber Technology (Contd.)

Fiber optic data link is made up of three elements as follows

- Light source at one end (laser or light-emitting diode [LED]), including a connector or other alignment mechanism to connect to the fiber. The light source will receive its signal from the support electronics to convert the electrical information to optical information.
- The fiber (and its cable, connectors, or splices) from point to point. The fiber transports this light to its destination. The light detector on the other end with a connector interface to the fiber.
- The detector converts the incoming light back to an electrical signal, producing a copy of the original electrical input. The support electronics will process that signal to perform its intended communications function.



1.2.6: Signal transmission optical fiber cable

Notes

Exercise

1. Identify the uncommon application of fiber optic cable?

a. Computer networks
b. Long-distance telephone systems
c. Closed circuit TV
d. Consumer TV

2. Principle of Fiber optics is

a. Reflection
b. Refraction
c. Dispersion
d. Total internal reflection

3. light transmission in optical fiber is in _____.

a. Core
b. Cladding
c. Buffer
d. Jacket

Exercise (Cont.)

4. Electrical to optical conversion is done through (Copper networks to fiber optics) using _____.

a. Fiber hubs

b. Media converters

c. Patch panels

d. Rewiring

5. Today, except for some _____, most of the Mobile/communication backbone lies in fiber optics.

a. Rugged or remote locations

b. Ultra-high speed connections

c. Large cities

d. Triple play systems

6. Write true or false after reading the following statement:

Advantage of optical fiber is, it is best cost-effective means of transporting information.
(True / False)

7. Write true or false after reading the following statement:

Fiber networks supporting Telephone networks for long distance and metropolitan networks like fiber to the home (FTTH) is not yet feasible (True / False)

Exercise (Cont.)

8. How does the telecom growth benefit the nation?

9. What is the brief history of India's telecom growth story?

10. Explain TRAI.

11. Briefly explain PSTN.

12. Mention what do the following terms stand for – BTS, BSC & MSC.

Exercise (Cont.)

13. What is the difference between multi-mode and single mode fiber?

14. What is fiber Id?

15. What are aramid fibers?

16. What is a ferrule?

17. What is scattering?

Tips

Following tips should be followed:

Visit a fiber optic site.

Inspect the different fiber optic cables and their features

Note

Skill India
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Transforming the skill landscape

1. Carry out inspection of Route Plan

Telecom Sector Skill Council

Unit 2.1 – Site visit and route inspection
Unit 2.2 – Choosing the right type of optic fiber cable
Unit 2.3 – Tools and tool kit
Unit 2.4 – Installation of fiber optic cable

TEL/N4137

Key learning Outcomes

At the end of this module, you will be able to:

1. Perform an effective site visit
2. Describe, demonstrate and monitor an effective route inspection
3. Choose between single mode and multiple mode as per the location
4. Describe the advantages of an effective route inspection
5. Identify and make use of common fiber optic tools and tool kit
6. Determine the availability of the test equipment as per the requirement
7. Explain and outline the benefits of fiber optic cable specification and the factors affecting it
8. Describe, demonstrate and monitor the correct procedure of handling the fiber optic cable
9. Describe, demonstrate and monitor the optical fiber laying pre-requisites
10. Identify instances of cross fiber using power source and power meter tests
11. Describe, demonstrate and monitor the correct procedure of - trenching, aerial cabling, ducting, figure-eight, cable pulling, blowing and termination of an optical fiber
12. Explain and illustrate the reports required to document steps undertaken during troubleshooting

UNIT 2.1: Site Visit and Route Inspection

Unit Objectives

At the end of this unit, you will be able to:

1. Perform an effective site visit
2. Choosing the right type of optic fiber
3. Explain and outline route inspection and its benefits
4. Perform an effective route inspection by demonstrating proper steps

2.1.1 Site Visit

Site visit is essential before making any plan of action. The visit gives the necessary information about the changes to be needed for the ideal plan. Site visit also emphasizes the action list with necessary competency needed. By doing effective site visit one could make the best plan of installation and avoid ambiguities. Obstruction which may prevent transportation of various equipments to the site could also be taken care. It is necessary to note down all the points observed start from layout view while site visit. While in the site data collected will equip informationso that proper, complete & accurate package for the same could be estimated. Site visit will make us understand actual equipment locations, routing for conduits, and proper elevations. It will help you to apply methods to overcome the challenges by applying the architectural drawings/ layouts. If found Site drawing details incomplete, then update it by site actual data. Note down the physical status, changes needed and plan further.

2.1.1 : A site visit in progress

2.1.2 Route Inspection and its Benefits

Route Inspection

Route inspection will give you an insight into what may confront you while performing your job. You may see obstructions, issues or gaps which you would have not known unless you conducted this 'inspection'.

Route Inspection Benefits

Following are the benefits of a detailed route inspection:

- Route inspection will give you an insight into what may confront you while performing your job.
- You may see obstructions, issues or gaps which you would have not known unless you conducted this 'inspection'.
- Plan is verified with the actual physical location to identify gaps.
- Helps in meeting manufacturer's specifications regarding 'bend ratios'.
- Plan is designed keeping in mind the health and safety standards.
- Any re-work due to lack of proper plan is avoided.
- Accidents are avoided due to proper planning.

2.1.2 : Effective route inspection

2.1.3 Steps – Route Inspection

Following are the steps for route inspection:

Step 1– Obtain an OFC route plan
Step 2– Verify the plan through a Route Walk
Step 3– Take corrective actions

2.1.3.1 Step 1 – Obtain OFC Route Plan

Obtain a 'layout' describing the proposed OFC route from the planning team so as to identify the:

Physical locations (premises or outside plant) along the route.

Other utilities, cables etc. so that damages are avoided.

Departments involved – electricity, water, municipality, etc.
Permission(s) required to carrying out the entire activity.

- Physical obstacles & health hazards along the route.

2.1.3.1: OFC route plan

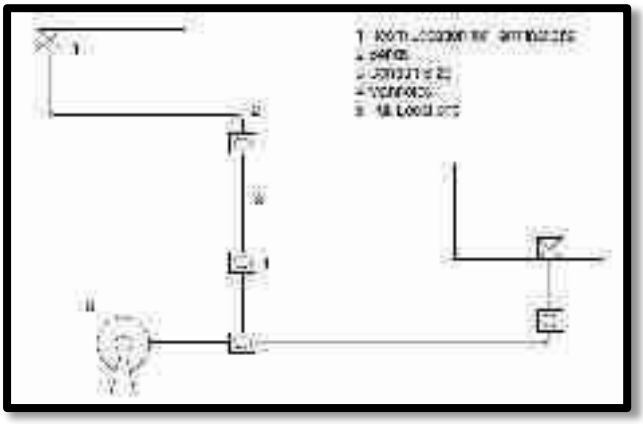
2.1.3.2 Step 2 – Verify Plan – 'Route Walk'

Conduct a 'Route Walk' along with 'Fiber Optic Technician' and an experienced 'Fiber Optic Splicer' so as to:

- Verify the 'plan' for accessibility and availability as per design.
  Verify construction methods, special tools, splice locations, etc.
- Verify ground characteristics including subsurface investigation; it helps allay fears related to trenching / ploughing
- Draw and mark bends, conduit size, splice locations, manholes, etc., so as to begin any preparatory or co-ordination work (Ref. next page).
- Mark the proximity to AC power areas to avoid possibility of damages / accidents
  Check for material storage areas, ventilation, etc.

2.1.3.2 (a): OFC Route Walk

Avoid proximity to AC power areas to avoid any accidents. Although the fiber does not conduct electricity yet, fiber could be means to conduct electricity, installer should take precautions with live electrical wires in working when close to AC power. Mark other utility lines so as to avoid damage. Thereafter make a sketch as per the route walk. It is called the **'Route Walk Sketch'.**



2.1.3.2 (b): OFC 'Route Walk'sketch

2.1.3.3 Step 3 – Take Corrective Actions

Prepare the site so that it is ready for installation by taking corrective actions with the help of laborers:

- Take permissions from other departments, etc., if required.
  Revise routes – bends, splicer locations, etc., if required.
- Arrange for the availability of any special tools if required.
  Remove or circumvent any obstruction / conflict along the route.
  Prepare the site thoroughly and properly for better productivity.
- Protect optical fiber cable from high temperature.
  Take measures to prevent optical cables from direct stress.
- Determine locations where reels are to be positioned during the installation.

2.1.3.3: Take corrective actions

Unit 2.2 Choosing the right type of Optical Fiber

Unit Objectives

At the end of this unit, you will be able to:

1. Choose the type of optical fiber based on the location
2. Define the characteristics of Single and multimode optical fiber
3. Explain how to select the type of optical fiber

2.2.1 Choosing between Single Mode vs Multimode Optical Fiber

The manner an optical wave is transmitted is often referred to as the mode. As they reach the optical fiber, uniformly frequencies optical waves are dispersed along several transmission routes. Mode is the name given to the specific path that each individual optical wave takes.

The Helmholtz equation for waves is used to compute the number of modes in a fiber optic cable. Applying boundary conditions to Maxwell's equation results in the actual Helmholtz equation. The projectile solutions of Maxwell's equation are the fiber optic modes as a result.

The modal dispersion phenomena that occur inside the fiber optic cable causes the modes.

Note: The quantity of glass fiber strands wrapped inside the cladding has absolutely no bearing on the modal dispersion.

Click/Scan the QR Code to know how Fiber Optic work

2.2.2 Overview of Single Mode Optical Fiber

Single mode optical fiber is a specific kind of optical fiber made for the transmission of single mode light. This indicates that this particular type of optical fiber allows the transmission of various light waves with various frequencies along a single channel. The preferred abbreviation for these single mode optical fibers in the sector is SMF. Transverse mode optical signals are carried via the SMF. This indicates that although the electromagnetic oscillation occurs in a perpendicular or transverse direction to the length of the fiber optic core strand, the path of the optical wave transmission is parallel to it.

Characteristics of Single Mode Optical Fiber

The following features of single mode optical fiber (SMF) make them exclusive :

- SMF features a micro core diameter of sizes ranging amid 8 to 10.5µm. The diameter cladding of SMF is approximately 125µm
- Laser rays being the basis of optical signals in SMF, the categorized optical wavelengths for SMF is 1310 nm and 1550 nm
- Ideally, SMF offers limitless bandwidth, as it offers a single light transmission mode at a time
- According to TIA-598C, the industrial color-coding or sheath colour for an SMF is yellow for non-military uses
- Owing to higher fidelity for all pulse of light wave coupled with smaller diameters, these
- SMFs are appropriate for long-distance transmission without excessive signal/data loss
- The SMFs can transfer the optical signal over hundreds of kilometres at a transmission speed of 40Gbps and above thousands of kilometres at the transmission speed of 10Gbps by using dispersion-compensation devices
- Depending on the variation in features, the single mode optical fiber (SMF) is classified. Let us discuss the classification of SMF further

Types of Single Mode Optical Fiber

The general types of single mode SMF are listed below.

OS1: The first type of SMF described in ISO/IEC 11801 is OS1. The core diameter of this kind of optical fiber is between 8 and 9 m. This fiber, however, experiences a greater attenuation of roughly 1dB/km. The signal weakens from one end to the other due to increasing attenuation. Because of this, this SMF is utilised for interior fiber-optic connections and relatively small distances.

OS2: OS2 is an SMF variant that is generally superior. In ISO/IEC 24702, it is described. Although it has a similar diameter of 8 to 9 m, the signal only experiences a slight attenuation of 0.4 dB/km. Lower attenuation means that the transmission's signal strength is constant. Installations of outdoor and long-distance optical fibers favour this kind of SMF.

2.2.3 Overview of Multimode Optical Fiber

A type of optical fiber created for the propagation of several light signals is the multimode optical fiber. MMF is the abbreviation used in industry for multimode optical fiber. According to the different optical signal wavelengths, modal dispersion occurs in MMF. The MMF has increased modal dispersion as a result. Depending on the refractive index of the glass core material, the optic wave propagation route in the MMF is either zigzag or semi-elliptical in shape.

Characteristics of Multimode Optical Fiber

The following characteristics of Multimode optical fiber (MMF) make them ideal for certain applications.

- The core diameter of MMF is greater, ranging from 50 to 100 m. The typical core sizes for the basic types of MMF, however, are 50 mm and 62.5 mm. The cladding's diameter stays at 125 meters.
- The classified optical wavelengths in MMF remain 850nm and 1300nm since the light sources are either vertical-cavity surface-emitting lasers (VCSELs) or light-emitting diodes (LEDs).
- Modal dispersion limits the MMF's range of operation. MMF bandwidth has a theoretical value of 28000MHz*km.
- The industrial color-coding or sheath colour for MMF is an orange or aqua jacket, per TIA-598C

- The MMFs are appropriate for short-distance fiber optic transmission because to their increased attenuation through dispersion. However, the transmission distance can be increased by utilizing proper fiber optic links.
- 100Gbit/sec data transport speed is available from MMF(magnetomotive force). MMF can transmit data at a rate of 100Mbit/sec up to 2km and 10Gbit/sec up to 550 meters in practice.

Types of Multimode Optical Fiber

Refractive index and signal behaviour, along with a classification scheme, are the major two criteria used to divide the multimode optical fiber (MMF) into two categories.

Based on System of Classification: Both the ISO 11802 and the TIA-492-AAAD classification methods are used to categorize multimode optical fiber. Let's understand about the following categories:

OM1: According to ISO 11802, OM1 is a category of MMF. It has a core diameter of 62.5 mm. These optical fibers provide more bandwidth and are FDDI-grade cable compatible.

OM2: According to ISO 11802, OM2 has a core diameter of 50 mm. It is intended to provide users more control over how light signals spread.

OM3: The core diameter of OM3 is 50 m, and it is also described by ISO 11802. This particular MMF, however, is made for laser-optimized propagation over VCSELs.

OM4: It is an MMF type that is specified by TIA-492-AAAD. Although it has a 50 m core diameter, it is made for high bandwidth, long-distance transmission. It supports transmission rates of 40 and 100 gigabits per second over a 125 meter distance.

Based on the Refractive Index and Signal Behavior: The behaviour or course of a signal varies depending on the refractive index of the material that makes up the core of the glass. The following types of MMF are established based on the same.

Multimode Graded Index Fiber: This kind of optical fiber has a core made of a substance with a graduated refractive index. This indicates that the refractive index of the core gradually decreases during signal transmission across a cable. The signal behaviour or path of propagation in this type of cable is semi-elliptical due to the graded refractive index. In this cable, attenuation and optical dispersion are reduced because of the same type of propagation.

Multimode Step Index Fiber: This variety of MMF has a core with a diameter of 100 m. There is a variation in the refractive index throughout the fiber as a result of the big diameter. Complete or partial refraction inside the core is caused by a randomly fluctuating refractive index at various refraction angles. In these kinds of MMFs, the result is that light propagates in a zigzag pattern

2.2.4 Difference between Single Mode and Multimode Optical Fiber

In addition to the features, there are several ways to describe the distinctions between single mode and multimode optical fiber. The highlighted distinctions between single mode and multimode optical fibers are listed below.

Impact of Optic Wave Propagation

As was said in earlier sections, it is understood that the modal dispersion and refractive index of the code glass material affects how optical waves propagate in different ways. The input and output signals sent by fiber optics are impacted by this variation in the propagation path. Let's talk about the effects of optical fiber cables that are single mode and multimode.

Single Mode Optical Fiber

Since modal and light dispersion are negligible in single-mode optical fiber, the light wave propagates linearly. As a result, there is less attenuation and the signal strength is constant. As a result, across a great transmission distance, the input signal and output signal are of equal strength in SMF. Additionally, all of the data packets arrive at the output end of the optical fiber since many optical waves with different frequencies may Communicate via SMF but they all take the same path. As a result, the security of data transfer from the source device to the receiver is maintained.

Multimode Optical Fiber

Let's understand about how both of the ways that multimode optical fiber cable transmits information affect the input and output signals.

Zigzag Light Propagation: Due to increased refraction, light dispersion and attenuation are higher in the zigzag form of light propagation in the MMF. As a result, with this kind of MMF light propagation, signal loss occurs. Additionally, because optical waves have zigzag transmission due to refraction at various angles with variable frequencies, each optical wave follows a distinct transmission path. As a result, light signals are transmitted at varying speeds using MMF. As a result, there is a chance that certain optic data packets will arrive at the recipient later than expected. Data is lost as a result.

- Semi-elliptical Light Propagation: Because the light beam does not hit the core wall during semi-elliptical propagation, there is less refraction and optical dispersion. The same causes just slight attenuation. Additionally, all light waves that propagate in this manner have a point-to-point semi elliptical shape. As a result, each wave arrives at the same location and is then transferred to the receiving device as a whole. Because of this, there is a very small loss of data packets.

Optical Resource Requirement

Both SMF and MMF installation require specific resources like light sources, connectors,

Single Mode Fiber

If placed for long-distance use, the SMF needs optical amplifiers to lessen dispersion in addition to a laser diode as a light resource. To inject the laser beam into the optical fiber, these components need to be calibrated precisely.

Multimode Optical Fiber

The MMF needs VCSELs or LED diodes as its light source. Additionally, if the MMF is installed for longer distance transmission, then the integrated circuit may need signal amplifiers, connections, and rectifier

Cost of Deployment

Despite being less expensive than multimode, single mode optical fiber cable nevertheless costs more to install than multimode fiber. This is due to the higher capital expenditure required for optical sources and integrated devices in the SMF network than MMF. In general, the equipment for laser diodes is 1.5–5 times more expensive than that for LED diodes. Additionally, SMF implementation costs may be higher than MMF due to the potential need for amplifier upgrades and system upkeep.

Application Compatibility

One of the distinctions between SMF and MMF is their compatibility with various applications.

Long-distance optical fiber networks, where the signal intensity is anticipated to remain at its greatest, use SMFs. Campus fiber optic connections, submarine fiber optic connections, distant office connections, etc. are examples of common applications for SMFs.

Fiber optic cables are mostly utilised with MMFs. These are utilised for telecom connections, LANs, video/audio/multimedia transmission, CCTV optic fiber connections, etc.

2.2.6 How to Select between Single Mode vs Multimode Optical Fiber

One must take into account a number of criteria while choosing between single mode and multimode fiber optics for a particular application. Considerable aspects include application requirements, fiber costs, installation system costs, equipment installation requirements, transmission distance and speed, among others. These selection parameters must be thoroughly compared before choosing either single mode or multimode optical fibers.

Comparison chart for convenient selection

S.No	Selection Parameter	Single mode optical fiber	Multimode optical fiber
1	Price of Fiber	Low	High
2	Price of Equipment and Installation	High (1.5-5 times more)	Moderate
3	Attenuation/ Signal Dispersion	Low	Moderate
4	Bandwidth	High	Low
5	Transmission	Low	High
6	Transmission Distance	High	Low
7	Data Reliability	High	Moderate

Exercise

Match column A with column B

S.No	Column A	Column B
1	Single mode optical fiber, if used for long distance need	Mode
2	First type of SMF described in ISO/IEC 11801 is	Optical Amplifiers
3	OM1, OM2,OM3 and OM4 are	OS1
4	the manner an optical wave is transmitted is often referred to as	Installations at outdoor and long distance
5	OS2 is used for	Categorization of Fiber

UNIT 2.3: Fiber Optic Tools and Tool Kit

Unit Objectives

At the end of this unit, you will be able to:

1. Describe the importance of maintaining a proper and complete tool kit
2. Perform a basic check of the tool-kit
3. List the tools with their respective quantity and usage

2.3.1 Fiber Optics Tool Kit

Fiber Optic Tool Kit

Right tools in best condition will ensure the best result in splicing and connectorization. It is suggested to keep the complete set of fiber optic tools needed for splicing, connecting, troubleshooting and testing. Fiber optic installer requires full list of fiber optic tools (needed start from installation to troubleshooting).

The tool kit primarily consists of:

- Testing equipment and testing supplies and consumables
- Cable handling tools.
- Termination/splicing tools and consumables
- Splicing splices

2.3.1 (a): Fiber optics tool kit

Click/Scan the QR Code to know about Fiber Optic splicing

2.3.1 Fiber Optics Tool Kit (Contd.)

Basic Checks

Ensure tools, equipment availability for testing, splicing, cable laying. Refer to the list of tools needed in the tools manual. In case of unavailability of any tool, get in touch with logistics team. In case of faulty tools and equipment, get in touch with logistics team. Keep your tool-kit absolutely clean.

Remember that these tools vary from organization to organization depending on their need and budget as the case may be.

2.3.1: Fiber optic tool kit basic checks

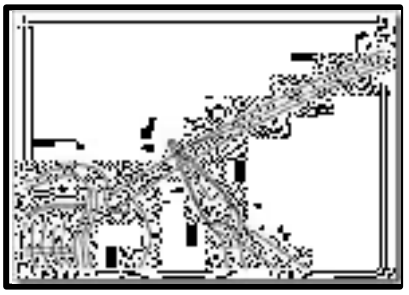
Notes

2.3.2Fiber Optics

Quantity	Tools For Installer's Toolbox		Overview
1	**Tubing Cutter – cuts through armored cable**		A regular tubing cutter is perfect for cutting the cable jacket and armor.
1	**Rotary Cable Slitting & Ringing Tool**		To cut cable jacket for removal - to cut around cable or slit jacket for removal
1	**Cable Jacket Stripper**		Used for cutting 2- 3 mm cable jacket for removal.
1	**Fiber Optic Stripper**		Used to remove primary coating from fiber without nicking the optic fiber. Some are also capable of cutting 2-3 mm cable jacket.
1	**Buffer Tube Stripper – to cut jacket/buffer tubes in loose tube cable**		Similar to some coax or UTP jacket cutters but must be precise to prevent fiber damage.
1	**Crimp Tool - crimps FO connector on the cable**		Must have crimp die appropriate for the crimp size required by the connector being used for termination.

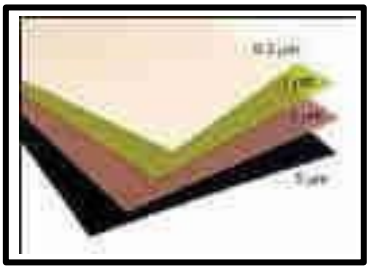
2.3.2 (a): Fiber optics tool list

2.3.2 Fiber Optics Tools (Contd.)

Quantity	Tools For Installer's Toolbox		Overview
1	**Kevlar Scissors – super-sharp to cut Kevlar fibers in FO cable**		Never use these scissors to cut anything else – they are expensive and will dull easily if used to cut other materials.
1	**Scribe – used to cleave fiber when terminating**		Sapphire or carbide are best.
1	**Needle Nose Pliers – use when accessing and pulling cords or ripcords.**		Do not use it for other things so as to damage its edges.
1	**Tweezers**		Do not use it for other things so as to damage its edges.
1	**Polishing Plate – place under polishing pad**		Need smooth surface for polishing.

2.3.2 (b): Fiber optics tool list

2.3.2 Fiber Optics Tools (Contd.)

Quantity	Tools For Installer's Toolbox		Overview
1	**Polishing Pad –place under polishing film**		Provides soft polishing surface for PC connectors
1	**Polishing Puck– insert connector into this polishing tool, lay on polishing paper**		Need one for 2.5mm ferrule connectors (ST/SC/FC) and one for 1.25mm ferrule connectors (LC).
1	**Safety Glasses**		Always wear safety glasses.
Optional	**Connector Curing Oven – to cure epoxy/polish connectors**		Epoxy/polish connectors are still the cheapest & most reliable and a portable curing oven allows fast installation.
1	**Lineman Scissors– heavy duty to cut through cables or other heavy materials**		Use these for general cutting - NOT your Kevlar scissors which are expensive & dull easily.

2.3.2 (c): Fiber optics tool list

2.3.2 Fiber Optics Tools (Contd.)

Quantity	Test Equipment		Overview
1	**Flashlight Continuity Tester (MM only) or Visual Fault Locator (VFL – red laser – SM or MM) – bright, visible light source for checking continuity or tracing fibers, VFL can find faults also.**		Continuity tester as a minimum, VFL recommended – the higher power makes it more versatile.
1	**Light source**		850/1300nm LED for MM, 1310 and/or 1550 for SM.
As needed	**Powermeter adapters**		One adapter can fit 2.5mm ferrules (ST/SC/FC) on some meters or may require dedicated adapters.
2 per test kit	**Reference Test Cables - tested and known to be low loss**		Need 2 each (launch & receive that match the fiber type (62.5/125,50/125 or SM) & connector types. If meter has universal 2.5mm adapter, you may be able to test all 3 types (ST/SC/FC) using one type with hybrid mating adapters, these wear out & need frequent replacement. Test and replace as needed.

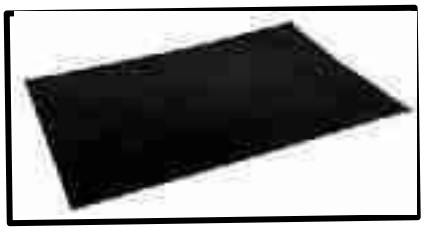
2.3.2 (d): Fiber optics tool list

2.3.2 Fiber Optics Tools (Contd.)

Quantity	Test Equipment		Overview
2 per test kit	Connector Mating Adapters – with metal or ceramic alignment sleeves (NOT PLASTIC)		ST/ST, SC/SC, etc. or hybrid ST/SC, etc. Note that just like reference cables, these wear out and need frequent replacement.
1	Connector inspection microscope		100-400X microscope with adapters for fiber optic connectors. Should have oblique lighting for best viewing of connector ferrule surface and IR filter to protecteyes from fiber optic source light in fibers.
Optional	ST Bare fiber adapter to test bare fibers		This is a connector with a clamp on the back that allows cleaving the fiber and using for tests.
Optional	Optical Time Domain Reflecto-meter (OTDR)		Used for OSP cables to verify splices and troubleshoot problems. Special OTDRs can also be used in premises if cables are sufficiently long.
Many	Alcohol-saturated pads - to clean fiber and connectors during splice, termination, test.		Must be pure alcohol since rubbing types have high water content that will cause problems with adhesives and fibers.

2.3.2 (e): Fiber optics tool list

2.3.2 Fiber Optics Tools (Contd.)

Quantity	Test Equipment		Overview
Many	**Lab wipes**		Use to clean up, dry off connectors after cleaning with alcohol pads.
1 per job	**Trash bin - small disposable container with top to hold fiber scraps**		1 pint deli container with lid works well.
1 per student	**Black work mat**		Helps see the fiber scraps to clean up black place mats or vinyl cut to size.
1	**Dry connector cleaner**		These have openings to push connector in, operate once to clean connector. Neater than wet cleaning, just as effctive.

2.3.2 (f): Fiber optics tool list

2.3.2 Fiber Optics Tools (Contd.)

Quantity	Termination Consumable Kit		Overview
Optional	**Connector curing oven - to -cure epoxy/polish connectors**		Epoxy/polish connector are still the cheapest and most reliable and a portable curing over allows fast installation.
Several	**Heat Cure, 2-Part Epoxy, 2.5 Gram**		"BiPax" package hasepoxy and hardener in plastic package that is mixed in the package. Can be used with many connectors at one time.
Several	**Cheap scissors to cut corner off epoxy package**		You will get epoxy on these when you cut the epoxy package so get cheap ones and discard after use.
1	**3cc Application Syringew/flat and needle to apply epoxy**		Make sure that it is not left in open air after use.
1 bottle	**Anaerobic Adhesive + Accelerator (optional) works well**		It is used for anaerobic connector termination.

2.3.2 (g): Fiber optics tool list

2.3.2 Fiber Optics Tools (Contd.)

Quantity	Splicing Kit		Overview
1	Fusion splicer		Many types and manufacturers are available.
1	Fiber cleaver		Most fusion splicers come with a quality cleaver. The same cleaver should be used with mechanical splices.
As needed	Fusion splice protectors		Use the type recommended by the fusion splicer manufacturer.
As needed	Mechanical splices		Many types exist, mostly used for restoration.
1	Mechanical splice tool(s)		Some mechanical splices require special tools to crimp the splice or fibers.
As needed	Wipes and reagent-grade (99%+ pure) alcohol (ethanol)		Use for cleaning fibers before splicing.

2.3.2. (h):Fiber optics tool list

2.3.3 Optical Power Meter (OPM): A Must for Fiber Cable Testing

A testing tool used to precisely measure the power of fiber optic equipment or the power of an optical signal transmitted through a fiber cable is an optical power metre (OPM), also known as an optical power metre tester or OPM tester. The OPM tester, which consists of a calibrated sensor that measures an amplifier circuit and a display, can be used to install, troubleshoot, and maintain any fiber network.

Additionally, it can adapt to different connector types like SC, ST, FC, etc. The optical power metre typically has five buttons: the POWER button, the LIGHT button, the dB button, the ZERO button, and the button. Below is a list of each button's functions:

An intuitive way to measure optical power is by looking at the optical power metre reading on the OPM screen, which is displayed in dBm units. The milliwatt reference power is indicated by the letter "m" in the term "dBm." The power of a source with a power level of 0 dBm is therefore 1 milliwatt. Similar to how 0.1 milliwatt equals -10 dBm and 10 milliwatts equals +10 dBm. The loss increases as a number becomes increasingly negative. OPM tests measure a negative number for loss, but in everyday speech, it is referred to as a positive number. For instance, the loss is 3.0 dB if the optical power metre reads "-3.0 dB". In addition, different network types result in different optical power ranges.

Network Type	Wavelength (nm)	Power Range (dBm)	Power Range (W)
Telecom	1310, 1550	+3 to -45 dBm	50 nW to 2 mW
Datacom	650, 850, 1300	0 to -30 dBm	1 to 100 uW
CATV, DWDM	1310,1550	+20 to -6 dBm	250 uW to 10 mW

Types of Optical Power Meter

OPM testers come in a variety due to resolutions that range from 0.001dB to 0.1dB. Depending on the requirements of the test, one should select an acceptable resolution for measurement. For instance, laboratory networks often require OPM testers with a precision of 0.01dB, whereas a few specialist fiber optic power metres have a resolution of 0.001dB.

Additionally, the physical limitations of transferring standards using optical connectors result in measurement uncertainties for fiber optic power metres that are essentially the same across the board. No matter what the display's resolution, most metres have an error of +/-5 percent, or roughly 0.2dB.

Fiber Optic Power Meter Test Procedure

An OPM tester and a light source are two pieces of handheld equipment required to evaluate a fiber optic system's performance from beginning to end. A wavelength of light is transmitted along the fiber by the light source. The power metre reads the optical power level of the light at the other end of the cable and calculates the amount of signal loss. Optical power metres should utilise the same wavelength as the light source since optical fiber loss varies with wavelength. For instance, the optical power metre should be set to 1310nm testing if the light source runs at that wavelength.

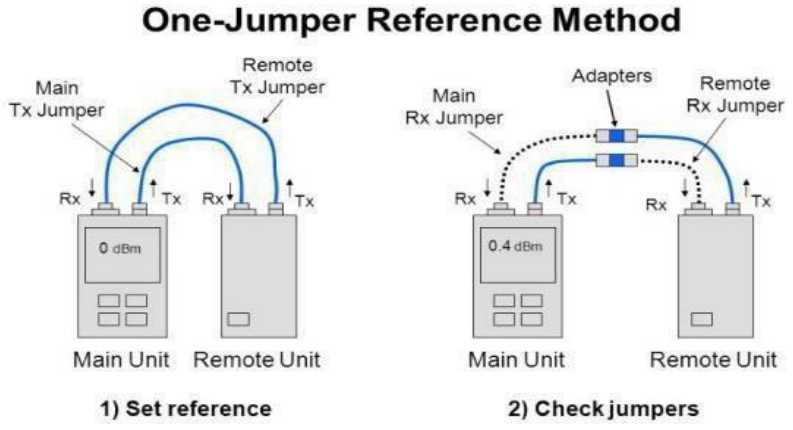
The one jumper method, also known as power metre and light source testing, is the most precise method for determining the fiber's end-to-end signal loss, or attenuation. The TIA/EIA-568 insertion loss limitations for each component are listed below. Stricter restrictions might be imposed by certain installations or protocols.

Loss budget (TIA/EIA specification limits)

Element	Insertion Loss
Splice	< 0.3 dB at all wavelengths
Connector Pair	< 0.75 dB at all wavelengths

The connection attenuation allowance should be matched to test results as follows:

Link Attenuation Allowance (dB) = Cable Attenuation Allowance (dB) + Connector Insertion Loss Allowance (dB) + Splice Insertion Loss Allowance (dB)



Exercise

Fill in the blanks:

1. _____ helps see the fiber scraps to clean up black place mats or vinyl cut to size

2. _____ use to clean up, dry off connectors after cleaning with alcohol pads

3 _____ provides soft polishing surface for PC connectors

4 _____ Used for cutting 2- 3 mm cable jacket for removal

5 _____used to remove primary coating from fiber without nicking the optic fiber

UNIT 2.4: Installation of Fiber Optic Cable

Unit Objectives

At the end of this unit, you will be able to:

1. Describe fiber optic cable specification – tensile strength, bend radius, crush and impact, cable attenuation, fiber optic connectivity, refraction, polarization and dispersion
2. Explain and outline factors effecting fiber optic cable – natural and man made
3. Demonstrate the correct procedure of – unloading, unwrapping, storage, drum preparation and opening of optical fiber cable
4. Demonstrate and execute optical fiber laying pre-requisites
5. Describe, demonstrate and monitor installation of optical fiber – trenching, aerial cabling, ducting, figure-eight, cable pulling, blowing and termination
6. Perform effective tests
7. Demonstrate effective reporting and documentation skills

2.4.1 Fiber Optic Cable Specifications – Tensile Strength

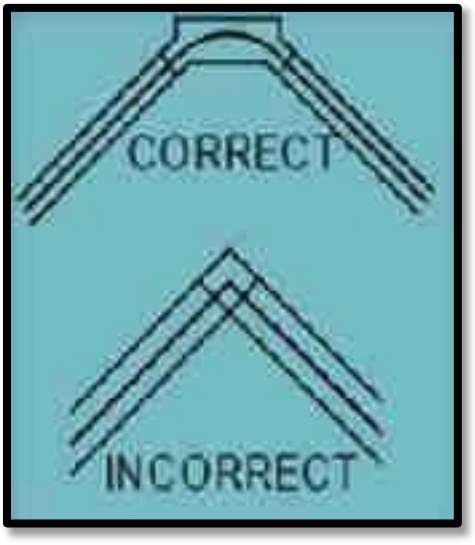
Tensile Strength - is the maximum load that can be set upon a link before any harm strikes the strands or their optical attributes:

- The maximum load that a cable can withstand at the time of laying is the short-term or installation load.
- The operating load is the load that impact on cable after the installation and it will be less compared to the installation load
- At the time of installation, the main concern will be to lay the cables with minimum load as possible. That's why there will be a definite tensile load value on every cable and the actual practical load should not be exceeded it.
- This is the practical permissible limit but not a cable damaging load.
- The maximum load that a cable can withstand at the time of laying is the short-term or installation load. The force may be because of pulling over sharp objects/corners or pulling through the ducts.
- At the time of installation itself, installers will measures and control the stress with which they pulling optical fibers to avoid sudden hard pulling.
- The load which will effect on installed cable will be less and this load value is termed as operating load or long term load.
- According to the application in which where we are laying the cable, both the tensile loads will be indicated on the cable sheath.

2.4.2 Fiber Optic Cable Specifications – Bend Radius

Bend Radius is the minimum radius that one can bend an optical fiber cable without damaging it. If the Bending is more than the permissible limit, the fiber loss will be more at the following points:

- Do not bend the fiber cable over a permissible radius limit.
- Like tensile loads there are 2 bend radiuses, installation radius and Static radius.
- The minimum bend radius value that a cable can sustain the attributes without any breakage at the time of installation is called installation bend radius. This bend will be higher (Radius should be minimum)
- The bend radius which is acceptable after the installation of optical fiber without any pulling force is called long term bend radius. The bend value will be less (Radius should be higher)
- Depends on the application of cable which where it is using these values will be different.
- The carelessness in the fiber handling will normally make the bend radii to exceed permissible value. Normally it will happen at the time of pulling cable through duct when the bend radii are too small.
- Cable should not bend exceed a permissible limit when it is going through trays or when installing.
- Optical fibers are very flexible to use in outdoor and indoor applications. Even though there should be chances of bending optical fiber cables in corners or at the near to equipments. These over bending can damage the fibers permanently.
- Another cause of damages in optical fiber is tight wraps around the cable normally at the user end



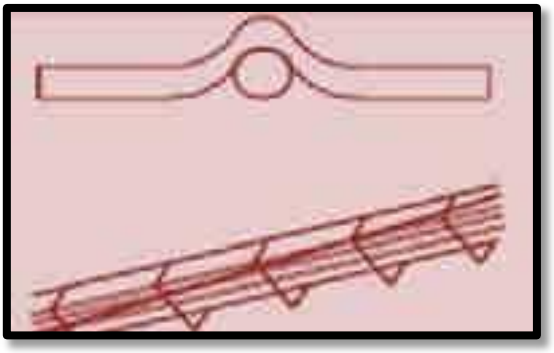
2.3.1.2: Bend radius

Click/Scan the QR Code to know the tips of installation of Optical Fibre Cables

2.4.3 Fiber Optic Cable Specifications - Crush & Impact

Crush and Impact helps to make sure however well an optical fiber can live through slow crushing or compression impact. The live cable will be crushed or compressed at any point to measure changes in optical power loss as per the test procedure. For every customer requirement permissible attenuation will be specified for a particular compression or impact force.

- To measure the changes in optical fiber characteristics and for the fiber breakage values the optical fiber cables may be tested.
- For the practical installation these crush and impact measurements are essential.
- The duct or tray which is using to run the heavier power cable can be used by optical fiber cables.
- It is better to avoid large compressive load on optical fibers, and to make that optical fiber cable should be lay on the top or sides of heavier cables. If the compressive load is more on fiber cables, it can produce physical damages.
- The chances of getting damage in installed optical fibers are more if they are shifting with a large weight on it.



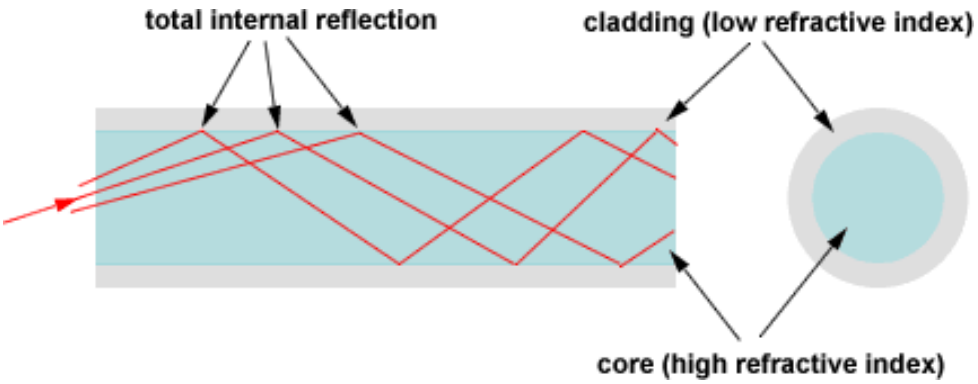
2.3.1.3: Bend radius

Notes

Refraction of Light

The phenomenon of a light ray changing direction as it travels through a transparent medium is known as refraction of light. The refractive index of the mediums determines how much the direction of the light ray varies.

Total internal reflection is the only foundation upon which optical fibers are built. The illustration below explains this.



A long, thin strand of ultra-pure glass, roughly the size of a human hair, is an optical fiber. To carry light messages across great distances, optical fibers are bundled together into optical cables.

The core, cladding, and buffer coating make up typical optical fibers. The fiber's interior, or core, is where light travels. The entire core is encased with cladding. Light in the core that strikes the cladding's boundary at an angle less than the critical angle will be reflected back into the core by total internal reflection because the refractive index of the core is higher than that of the cladding.

The core diameter spans from 8 to 62.5 m for the most popular varieties of optical glass fiber, which include 1550 nm single mode fibers and 850 nm or 1300 nm multimode fibers. The most typical diameter for cladding is 125 m. Typically, buffer coatings are made of acrylic or nylon, two types of soft or hard plastic with diameters ranging from 250 to 900 m. The fiber is protected mechanically and has bending flexibility thanks to buffer coating.

Polarization-maintaining optical fiber:

In fiber optics, polarization-maintaining optical fiber (PMF or PM fiber) is a single-mode optical fiber in which linearly polarized light, if properly launched into the fiber, maintains a linear polarization during propagation, exiting the fiber in a specific linear polarization state; there is little or no cross-coupling of optical power between the two polarization modes. Such fiber is used in special applications where preserving polarization is essential.

Specialized uses for polarization-maintaining optical fibers include quantum key distribution, interferometry, and fiber optic sensing. Since polarised light is needed as input for the modulator, they are also frequently employed in telecommunications to connect a source laser and a modulator. Due to its high cost and lower attenuation than single-mode fiber, PM fiber is rarely employed for long-distance transmission. Fiber-optic gyroscopes, which are frequently utilised in the aerospace sector, are another significant use.

The polarisation extinction ratio (PER), which is the ratio of correctly to wrongly polarised light and is given in dB, is commonly used to describe the output of a PM fiber. With the use of a PER metre, PM patch cord and pigtail quality can be assessed. Extinction ratios in excess of 20 dB are a sign of good PM fibers.

Polarization control using different fiber squeezes:

2.4.4 Fiber Optic Cable Specifications Attenuation

Attenuation is the decreasing optical power when a light signal is travelling from sender to receiver. There are different classifications of attenuation, according to the cause of loss in power. Attenuation can happen because of Absorption, Scattering, Birefringence, and Bending etc.
Optical attenuation is termed in dB (decibel).

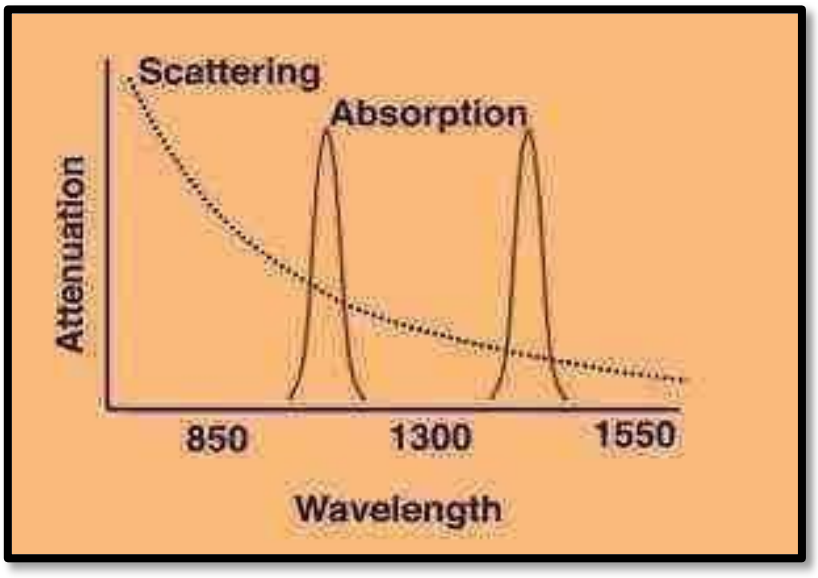


Fig. 2.3.1.4: Cable

Attenuation in Optical Fiber

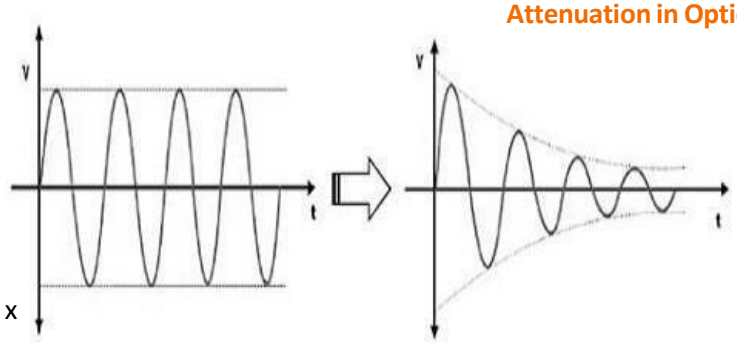


Fig 2.3.1.4: Attenuation in Optical Fiber

Attenuation:

Attenuation refers to the weakening of a signal and can affect any sort of transmission, analogue or digital. Because this is a typical result of a signal while it is transmitting across long distances, in some circumstances it might be referred to as attenuation loss. This can be expressed in terms of DBs (decibels) for each foot, kilometre, thousand feet, etc. in some cables, such as conventional or FOCs (fiber optic cables). When the attenuation for each unit distance is low, the cable efficiency is high.

A repeater or repeaters must be added to the length of any cable when it is necessary to transmit signals over vast distances. Because repeaters are crucial in boosting the signal's intensity to overcome this. So, this improves communication at its highest possible level.

There are different types of attenuations which include deliberate, automatic, and environmental.

Deliberate: Wherever a volume control can be used to lower the sound level over consumer electronics, this form of attenuation may occur.

Automatic: By detecting automatic level to activate attenuation circuits, this type of attenuation is used to stop the distortion of sound in TVs and audio equipment.

Environmental: This type of attenuation refers to a reduction in signal strength caused by the transmission medium, which may be wireless, fiber optic, or coupled to copper wire

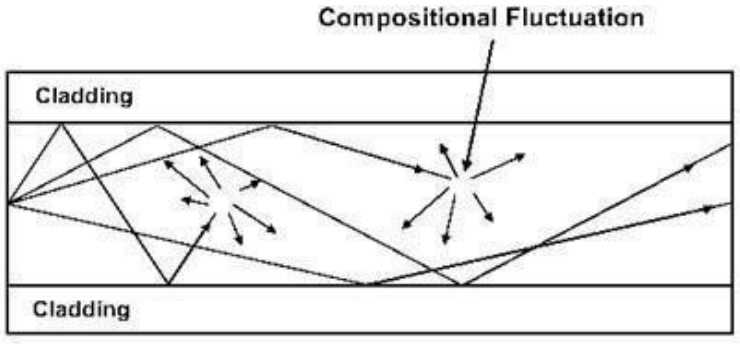
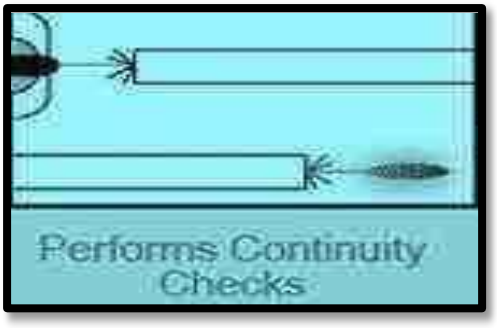


Fig. 2.3.1.5: Attenuation

2.4.5 Fiber Optic Cable Specifications Continuity

Fiber end continuity is the testing method using to verify the optical signal delivery at the receiver side of the communication system. It is working by measuring the optical signal power at the both end of the fibers and also can be works by checking the reflecting light intensity. If the reduction in the intensity of light pulses is 'insignificant' or 'zero' the continuity is good and the OFC is fine.



2.3.1.6: Fiber optics continuity checks

2.4.6 Dispersion in Fiber Optic Cable

Dispersion in optical fibers

The process by which an input signal broadens/spreads out as it propagates/travels down the fiber is referred to as optical fiber dispersion. Modal, chromatic, and polarisation mode dispersion are the typical types of dispersion in fiber optic cable.

In multimode fibers and other waveguides, a distortion mechanism known as modal dispersion causes the signal to be spread out in time as a result of the various modes' varying rates of propagation. As is common knowledge, light rays entering a fiber at various angles of incidence will follow various routes or modes. As shown below with a step-index multimode fiber, some of these light rays will travel directly through the fiber's centre (axial mode), while others will continually bounce off the cladding/core barrier and zigzag their way through the waveguide. Modal dispersion (or intermodal dispersion) occurs whenever there is a bounce off. The model dispersion will increase as the path lengthens.

The varying speeds of light rays cause a phenomenon known as chromatic dispersion, which is the spreading of a signal across time. The effects of material and waveguide dispersion combine to create chromatic dispersion

Chromatic Dispersion

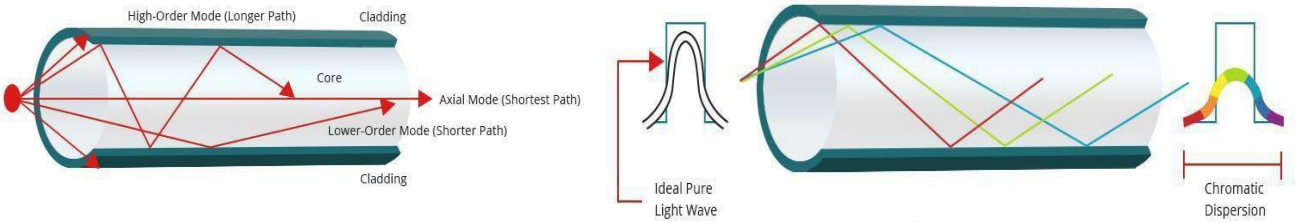


Fig. 2.3.1.7: Chromatic Dispersion

The polarisation dependency of the properties of light wave propagation in optical fibers is represented by polarisation mode dispersion (PMD). The propagation characteristics of light waves with various polarisation states typically varies slightly in optical fibers. When considered as an energy wave or area, light has two axes that are perpendicular to one another, the electromotive force and the magnetomotive force. PMD happens when the energy in these two axes moves at a different rate in a fiber.

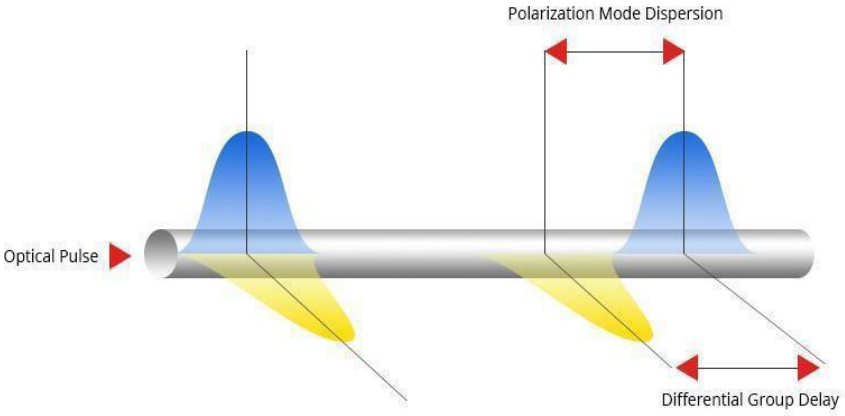


Fig. 2.3.1.8: Polarization Dispersion

Despite the fact that optical fiber dispersion can spread and distort information in many different ways over time, it is not always detrimental to the transmission of telecom signals across fiber optic networks. When employing wavelength division multiplexing, it is really preferable to have some dispersion because it could lessen the impacts of nonlinearity

A technique for multiplexing several services onto optical light lines is provided by the telecommunications industry standard protocol known as optical transport networking. It was initially intended to encourage the expansion of networks beyond SONET/SDH.

Technological solutions like OTN are being modified as network service providers deal with the ever-growing challenge of rapid user growth and increasing digital traffic, with things like mobile apps, social media, cloud computing, VoIP, and video chatting.

The majority of contemporary networks are packed-based and feature multiple services and applications with varying demands on bandwidth and transmission performance, in contrast to circuit-based networks of the past, which frequently consisted of predictable connections between pairs of endpoints.

The information structure is called the Optical Transport Module (OTM).

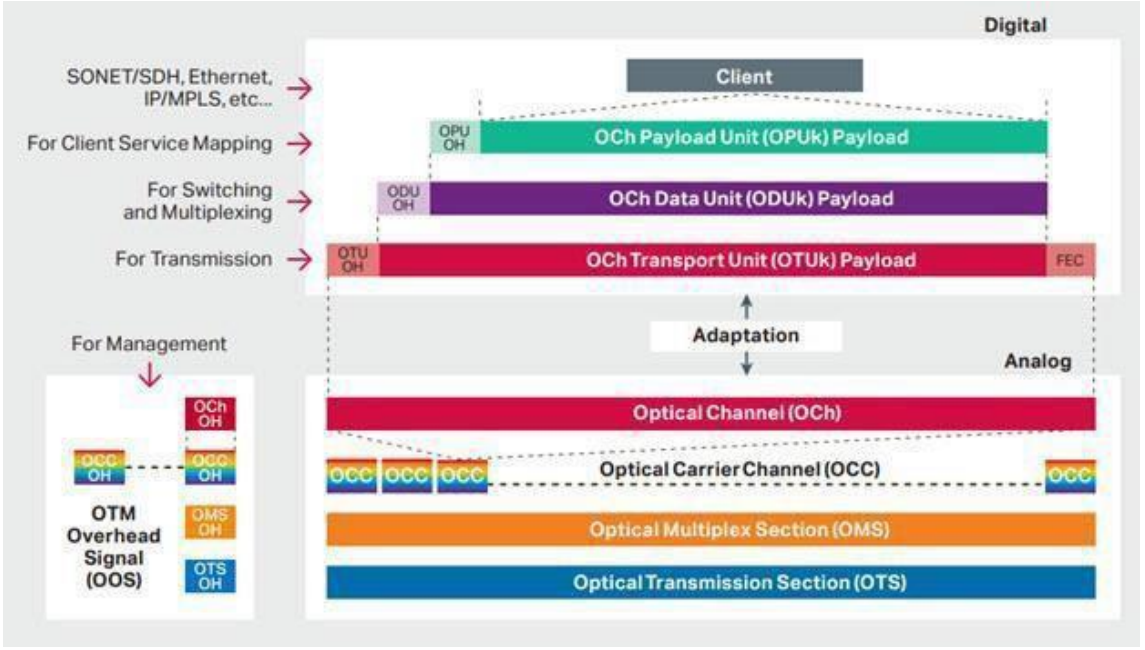


Fig 2.4.6.1 : Optical Transport Module

Benefits of Optical Transport Networking

Lower cost: OTN provides an economical method of filling optical network wavelengths and eliminating excessive expenditure by transporting numerous clients on a single wavelength.

Performance: OTN enables performance to be managed for each client by allowing individual configuration of bandwidth to each service or group of services.

Spectral efficiency: By guaranteeing constant fill rates all throughout a network, OTN offers efficient use of DWDM capacity.

Flexibility: OTN networks let operators customise the technologies they use at the moment while also allowing for the adoption of new ones as and when clients demand them.

Security: OTN offers a high level of privacy and security because to the use of hard segmentation of traffic on dedicated circuits.

2.4.7 Signal strength and quality KPIs of Optical Fibre

The Three C's of an Optical Fiber: The "three C's" are the fundamental components of an optical fiber in terms of fiber testing:

- **Core:** A carefully treated glass or plastic that makes up the fiber cable's centre. This must be as pure and clean as possible because it serves as the conduit for the transmission of light throughout the entire wire.
- **Cladding:** To enable consistent reflection of the light source back into the core, an extra layer made of material comparable to the core but with a lower refractive index is added.
- **Coating:** The cable's outer layer, which encircles, shields, and insulates the core and cladding.
- **Optical Loss Measurement**: The power output of the light source drops as it travels through the fiber. Decibels are used to express the optical loss, or drop in power level (dB).
- Fiber testers can measure the overall optical loss in a fiber most precisely by injecting a known amount of light into one end and using an OLTS to measure the amount of light at the other end. This approach needs access to both ends of the fiber because the optical light source and power metre are attached to different ends of the network.

.

Optical Power Measurement: A power measurement is a test of the transmitter's signal intensity once a system has been turned on or activated. An optical power metre, which can be attached to the output of the optical transmitter or to a fiber cable at the location of the optical receiver, will show the optical power received on its photodiode. The unit of measurement for optical power is "dBm," where "m" stands for 1 milliwatt and "dB" for decibels.

Testing Fiber for Optical Loss

Fiber testers must be connected to a test source to provide an optical light standard and a launch cable to offer a calibrated "0 dB loss" reference for testing fiber optic cables for optical loss. To determine the loss in dB of the fiber itself, a power metre at the other end of the circuit will measure the light source with and without the fiber under test.

Launch cables and "receiving" cables attached to the power metre are additional ways to verify fiber optic cable connections. The loss measurements at both test cable connection ends are included in this standard test for loss in an installed cable plant. Because of this, a crucial component of every fiber test is making sure all connections are exceptionally clean.

You may assess optical loss in fiber optic cables using an optical time domain reflectometer (OTDR). The OTDR equipment examines the backscatter of light that is returning to the source location using high intensity laser light that is emitted at pre-determined pulse intervals through a connecting connection at one end of the fiber optic cable run.

2.4.8 Factors Effecting OFC

- Incorrect specification of Fibre optic cabling

If the speed you wish your network to run on doesn't have the correct fibre optic cabling installed, it will never run at the desired speed. For example for 10Gig speeds and links the maximum cable length you can run the fibre optic cable ranges from OM1 (33metres), OM2 (82metres), OM3 (300metres) to OM4 (400metres). Exceed this distances or pick the wrong fibre optic cable and your network will not perform at the desired speed and standard

Consideration between singlemode and multimode fibre optic cable choice. Singlemode fibre cable is a single core of fibre cables vs a multimode fibre cables is made up or glass modes along the cable. Singlemode light transmission is via a laser rather than a light source so although the speeds and distances achievable are greater the overall cost of the link and hardware are greater.

- Poor connector terminations

The connector starts with firstly making the correct choice of fibre optic connector. The fibre optic connector chosen must match the existing patch panel connectors as the different types are not interchangeable and don't fit into one another

The ST fibre connector was the connector of choice for some time but has been surpassed by the SC and LC connectors with the LC now the connector of choice for its performance and low density patching characteristics

Additionally if the fibre optic cabling connector ends are poorly terminated or the ends bent too sharply then the light passing through will either be limited or at too low a range for the transmission to be connected. Light could still be shining through a fibre optic cabling links but not have enough transmission quality to create the data link.

With fusion splicing and correct terminations, standard optical fibre cabling speeds can be guaranteed.

- Dirty connector ends

If the fibre optic cabling connector ends become dirty then the transmission can be intermittent or not work at all. Keeping the unused optical fibre cabling connectors covered when not in use goes a long way to alleviating this problem

Dirty connector ends can be caused during the termination process but are more commonly caused during un-patching and re-patching of fibre optic patch leads and links. Care should be taken to clean the fibre optic ends each time patching is undertaken

- Poor installation

Fibre optic cabling has a specific bend radius and pulling tension guideline when installing the main cabling runs. If the cable becomes stretched or bent too tightly then the quality of light down the cable is compromised resulting in a poor or non-existent performance.

Cable	Cable Structure		
Parameter	Loose Tube	Tight Buffer	Breakout
Bend Radius:	Larger	Smaller	Larger
Diameter:	Larger	Smaller	Larger
Tensile Strength: (Install):	Higher	Lower	Higher
Impact Resistane:	Lower	Higher	Higher
Crush Resistance:	Lower	Higher	Higher
Attentuation Change at Low Temperatures:	Lower	Higher	Higher

that affect the cable

Cable	Cable Structure		
Parameter	Loose Tube	Tight Buffer	Breakout
Bend Radius:	Larger	Smaller	Larger
Diameter:	Larger	Smaller	Larger
Tensile Strength: (Install):	Higher	Lower	Higher
Impact Resistane:	Lower	Higher	Higher
Crush Resistance:	Lower	Higher	Higher
Attentuation Change at Low Temperatures:	Lower	Higher	Higher

2.4.9.1: Choice of cables consideration factors

Notes

2.4.10 Handling Optical Fiber Cable

Optical fiber Cable Handling:

- Optical fibers are easily getting damage at the time of installation because of careless handling. These damages will largely affect the performance of the communication system and sometimes cable need to be replaced.
- We must handle the cable appropriately as described in subsequent pages to avoid these situations.

Cable Unloading

Following precautions need to be taken during the cable unloading:

- At the time loading and reloading the optical fiber cable drum should not drop from height as the load can damage the fibers inside the cables.
- At the time of reloading from truck roll the drum from it to floor or platform, which should be in a same height or otherwise use forklifts.
- Forklift has to be used when unloading it from truck.
- Use inclined ramps to roll the drum with control
- Roll cable drums one at a time on ramp.

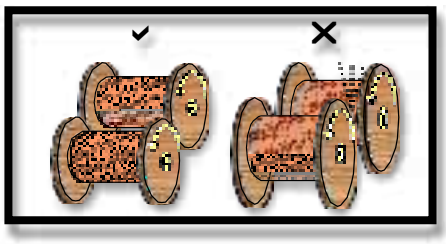
Cable Unwrapping

Following precautions need to be taken during the cable handling:

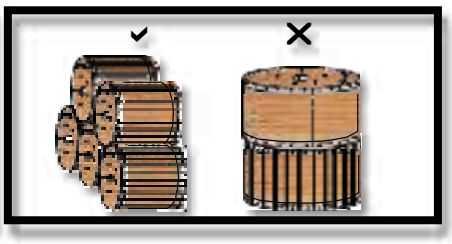
- Every cable drum has to be wrapped by wooden laggings to avoid damage by impacts or to protect from sudden rolling of drum on rough surface. So it has an essential role in cable protection.
- Remove the wrapping completely only at the time of installation

Cable Storage

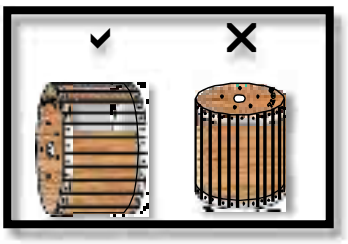
- The best storage position of the drum is upright; otherwise winding effects can cause damage on it.
- In some situations, storage space will be less and on these places drums should be stacked. So the stack should be wrapped with the flanges edge of drums.
- To avoid the overlapping of flanges with the cables after removing entire wrap the drum should be aligned as the flanges should touch each others.



2.4.10 (a): Handling OFC



2.4.10 (b): Handling OFCC



2.4.10 (c): Handling OFC

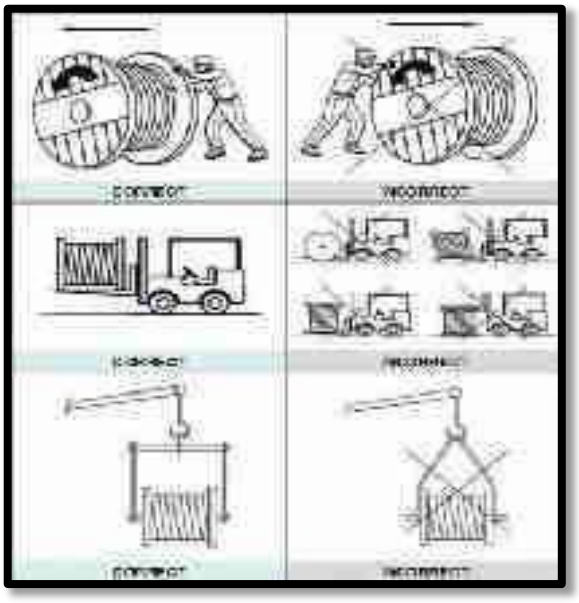
2.4.10 Handling Optical Fiber Cable (Contd.)

Environment Storage Issues

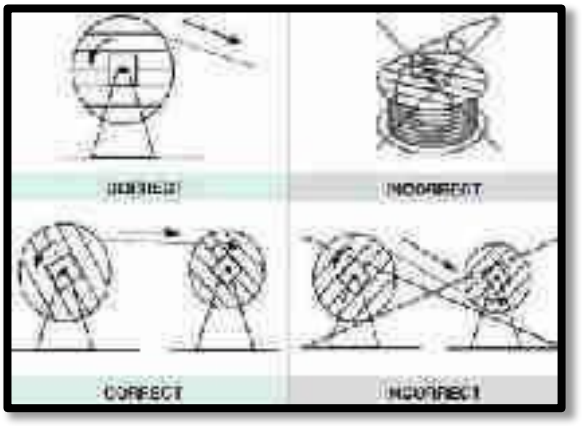
- Wooden drums are using to wound optical fiber cables. After some duration of time these wood gets degraded due to environmental actions.

Important Way to Address the Same

- Recommending Indoor storage of drum to avoid the degradation.
- The storing platform should be hard and moist free to avoid degradation.
- The wooden parts should not be in touch with any moist soil to avoid the generation of wooden degrading insects.
- Use polythene sheets to cover the drum stacks in outdoor storage areas to avoid degradation due to rain. The drum moisture content should not more than 25%.To protect the drums from these situations in-house storage prefers.



2.4.10 (d): Handling optical fiber



2.4.10 (e): Handling optical fiber

2.4.10 Handling Optical Fiber Cable (Contd.)

Pre Installation - Drum Inspection

Check the drums for the following:

- Before shifting drums from storage space to sites all the drum should be check and verified by continuity breakage and damage inspections.
- The important drum parameters or specifications like fiber count & type, meter marking, cable length, manufactures details etc. Should be marked on the drum flanges.
- All these verifications should be done before taking it to shift from one place to another.

Cable Inspection

Check the cable for any damage:

- In case of doubt, remove lagging & examine cable thoroughly.
- Continuity test should be done for every cable.
- Total length and the total attenuation should be measures and marked
- At the time of shipping itself, check the damages and inform suppliers.
- Inner and Outer ends should be located for every cable drum.
- Pulling grips and end caps should be removed from the cable before taking it to sites.

Apart from making sure that the correct type and quantity of cable was shipped from factory, it is necessary to inspect each drum for damage. Before installing cable, test all fibers for their optical continuity, attenuation and length; if any deviation is found inform the supplier immediately.

Opening Drum

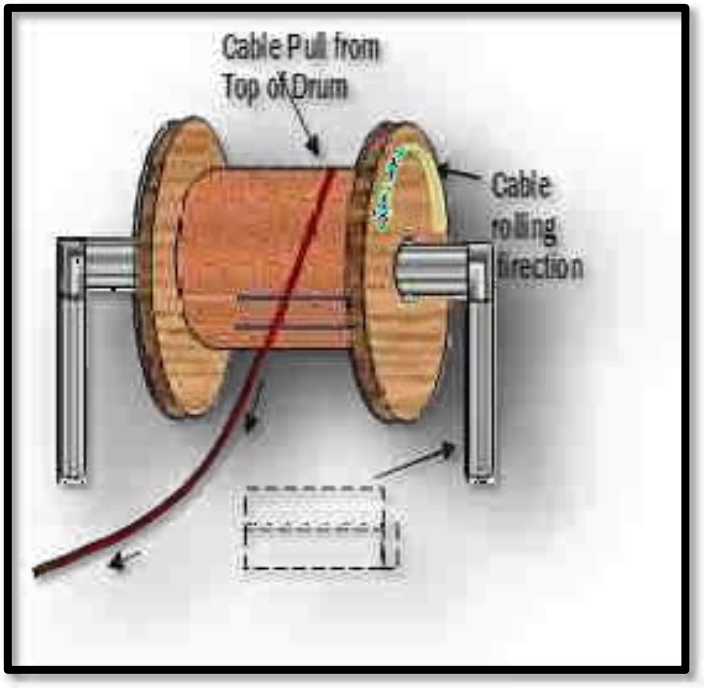
Open the drum carefully keeping the following in mind:

- Optical Fiber cables are protected by enclosing it with wooden batten nailing on the flanges of drum with aluminum or iron strip .It can avoid damage of fibers when it transporting from one location to another. For laying the cable at the installation site, it has to open without damaging the fiber.
- Strip cutters can be used to cut the aluminum or iron strip safely.
- Wooden batten should be taken out safely with hammers.
- Nails also should be removed or bend it to avoid injuries while handling the drum.
- Remove thermal wrapper applied over cable.

2.4.10 Handling Optical Fiber Cable (Contd.)

Preparation of Drum

- The reel or drum mounted on a shaft which can roller payoff. For the easy roll of action the pulling direction and the payoff orientation should be same and take out the cable from the roller from top to avoid cable contact with platform.



2.4.10. (f): Preparation

Notes

2.4.11 Installation of OFC

The actual installation process basically involves pulling cable, terminating and testing it. Pre-requisites to do the same are to:

- Keep the cable pulling plan handy.
- Keep copy of all the permits handy.
- Keep all the tools & equipment & emergency plan handy.
- Share the cable pulling plan with all the relevant stakeholders/installation team.
- The location of intermediate access points, splice locations and the specific responsibilities of each member of the installation team.

Notes

2.4.11 Steps OFC Installation

Work to convert the designed system to operating communication system. A contractor comes in between user and the network owner to establish the real connection. The main roles of contractor are design, installation, testing, trouble shooting, documentation, and restoration. The contractor must have the experience on the network installation and should have the same like reference works to submit.

Following are the steps for installing optical fiber cable:

Step 1– Installation through

(a) Trenching or (b) Aerial.

Step 2– Ducting process.

Step 3– Conduct figure 8'ing'.

Step 4– Cable pulling and blowing.

Step 3– Cable termination.

2.4.11.1 Step – (a)Trenching

Trenching is a process of making a narrow excavation on earth along a short distance. It involves digging, placing cables and refilling. Trenches can be made by several methods like manually by hand tools, excavation machineries etc. After digging, it should be visually inspected and verify that there should not be any rocks, debris or sharp objects to damage the cable. This process need more man power and time to establish and it is the most effective installation method/Laying method for shorter distance applications. Most normally after dug trench a conduit made up of concrete or plastic will laid throughout the trench to make the fiber lay quite smoothly and also it can avoid the repetitive trenching to pull again cable between access points in future.

Ploughing is also used for the cable lay, where dig a narrow channel, place fiber cable on it and cover it with the soil. There are some machineries to plough and directly reel off the cable and the same system can cover it with mud. This system is quite fast on their work, will reduce the manpower and time. That's why, ploughing is used for the long distance application and it is less catastrophic to soil. The cable which laying after plough is directly buried and so the depth of channel should be more compare to trench to providing more protection. But again the actual depth will be varying according to the application and characteristics of cable which using. So the direct buried process is more beneficial when it comes with cost and time.

2.4.11.1 Step – (a) Trenching(Contd.)

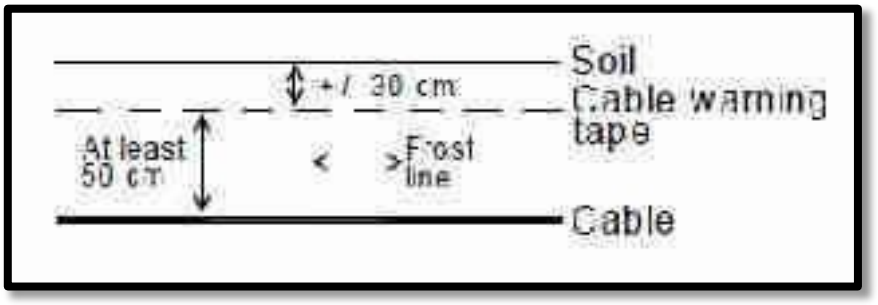
- Trenches are done where the excavation will be hard because of more obstacles are present and normally at urban and sub urban areas to laying optical fiber cables.
- Trenching is a process of excavating, placing cable and refilling. Trenching is conducted by using machinery or manually. Trench dimension will vary according to the applications. Every cable termination point will be sealed and protected by protective caps.
- Route markers and warning tape will be used to protect the underground cables from future excavation. Underground cable will be buried under a standard depth to avoid the accidental damages by being dug up.
- The normal depth at which the trenches are made is 3-4 feet from the ground.
- The first process is digging a narrow channel and duct placement along the distance with pulling tape will be provided inside for the actual pulling process of cable in future.
- There are various types of ducts are available in market and the duct selection will be depends on characteristic of soil where we are installing. If the dielectric duct is using, normally a conductive marker will be placed on the ground level to get noticed by workers and pedestrians to avoid the dangers.
- Trenching conducted normally by machineries and in some areas manual trenching is also done by using hand tools. But the manual trenching will take more manpower and time. To complete the trenching in maximum speed, trenching width and depth will not goes over requirement.

2.4.11.1 (a): Trenching

2.4.11.1 Step – (a) Trenching(Contd.)

Precautions of Trenching - While using 'trenching' for installing the OFC following precautions must be taken:

- Buried cable to be located in a manner that it is not moved
- Trench route should be select by considering the future development planning in those areas. Road widening should not disturb the installed fiber cable.
- Route selection of cable trench should consider the natural drainage holes on the particular location.
- Need to use a route marker and should be placed on the surface where underground cable is laid.



2.4.11.1 (b): Trenching

2.4.11.1 Step – (b) Aerial Cabling

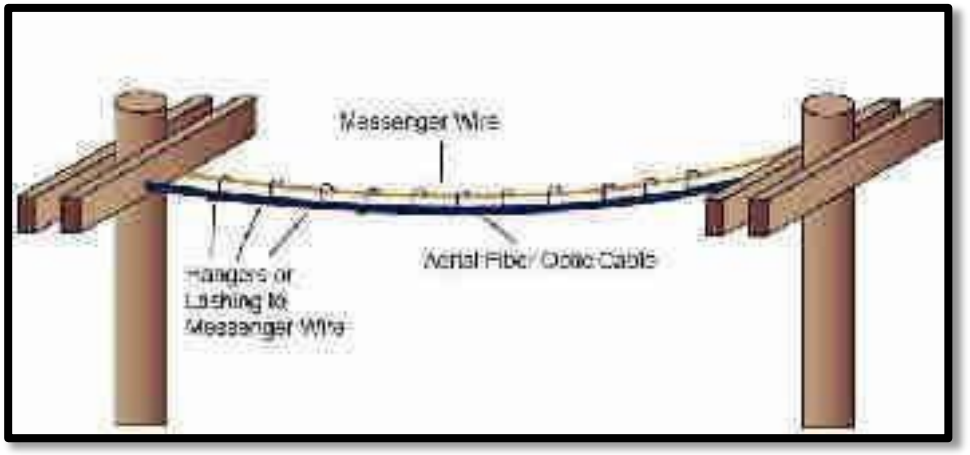
There is another type of cable laying which is generally using in outdoor sites like direct buried is Aerial installation. Specialized Aerial cables are using for this pole-to-pole installation. The installation of aerial cable is executed by specialized companies. Aerial installation needs sophisticated equipments for the long-distance applications. Optical fibers are lightweight and flexible but the cables which designed to install outdoors are made with high tensile strength. Aerial cables may be subjected to high pulling force because of wind, ice, and other environmental factors. These factors can cause the cables to pull on the cable or sag. To avoid the damage of cables because of this sag force, normally aerial cables will be supported by a specialized messenger cable made of steel with strong tensile force capability along the route. So, the aerial cable will be laid along with messenger wire and at every particular length they will be tied or lashed together. To avoid any kind of dangers due to electrical conductivity between the conductive cables and messenger wire, they will utilize dielectric threads to lash. According to requirements of support on messenger wire, they will select the number of threads in particular distance. Generally, there should be at least one lash/tie per foot. According to the application, cable laying distance, type of cable using the type of messenger wire also will vary. There is one method that cables can be tied or lashed on the existing

2.4.11.1 Step – (b)Aerial Cabling

It is an armor buffered tube fiber cable with the following key features as depicted in the picture. Aerial cable is:

- Supported by poles (Telephone/electrical towers) (is tough for the same reason) - is used where outdoor conditions prevent OFC burial or where aerial infrastructure is present– telephone poles or electrical towers.
- There are two types of cable installation that self-supported (no need of messenger wire) and tied/lashed.
- Susceptible to – load, wear & tear etc. as it stands exposed.
- Messenger wires & hangers are used to prevent it from sagging.

2.4.11.1 (c): Step – aerial cable



2.4.11.1 (d): Step – aerial cable installation

2.4.11.2 Step – Ducting Process

The duct used in outdoor applications is providing an extra protection to the optical fiber cables from rodent penetration and other damages. Also these ducts are providing an extra easiness in the cable laying and pulling. Ducts are made up of rigid, abrasion resistant material. These conduits are buried directly and cables are laying through it. By using series of ducts and conduits under the cities, where they lagging the physical spaces to accommodate fiber plant, they are utilizing underground plant and accessing it through manholes or access holes. Once a duct laid, it will provide a new route for new cables and it is very easy to remove old cable without damaging the optical fiber cables. It will also avoid making further disturbance to streets, footpaths and other public constructions. Mostly these ducts will have a pull tape or rope to make the future run easy. Sometimes the duct will be placed without any cables inside and it will be used in future for the upgradation. Inner ducts will also play major roles in the optical fiber cable laying. It will be in a physical condition that, it can easily place inside outer big ducts. The inner ducts colors are using for the identification purpose in maintenance and it will be clear and clean for the new fiber installation.

- Ducting is done either manually or through machine.
- It is made of PVC (Poly Vinyl Chloride).
- Duct diameter must be at least twice the OFC.
- Duct should have pull ropes or tapes to ease future runs.
- Ducts have inner ducts or lining to avoid damage to OFC due to rubbing; in various colors they assist in cable identification and maintenance.
- Required length of duct is measured by the installer.
- Length of duct is properly unwound & put in position.
- Duct is fed through the path after which refilling is done and path is restored with grass or tiles as may be the case.
- Ensure ducts are clean, without twists, collapsed portions, with ends sealed - using end plugs (to avoid – mud, water or dust).
- Ensure duct joints are airtight.

2.4.11.1 : Ducting process

2.4.11.2 Step – Ducting Process (Contd.)

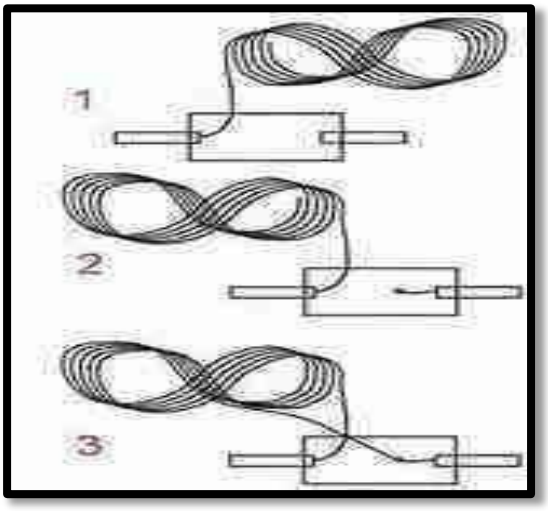
Following is the underground duct – advantages

- Duct is providing an extra protection to the optical fiber cables from rodent penetration and other damages, but it can provide following advantages
- Conduits are excellent for installing tight buffered cables.
- Duct can avoid the rodent penetration.
- Duct is an economic way of installing optical fibers where the repeated ploughing and refilling is difficult or impossible to carry out.
- Bundle of Ducts/conduits are laying under the street to create underground plant and also can access it by manholes.
- It will also avoid making further disturbance to streets, footpaths, and other properties.
- Duct will have a pull tape or rope to make the future run easy.
- Sometimes the duct will be placed without any cables inside and it will be used in future for the upgradation.
- Inner ducts will also play major roles in the optical fiber cable laying. It will be in a physical condition that, it can easily place inside big ducts.
- The inner ducts colors are using for the identification purpose in maintenance, and it will be clear and clean for the new fiber installation.
- Inner duct will make sure that the inner path is clear and clean for smooth laying and pulling where if ducts are already filled with multiple cables.
- Ducts can avoid the further disturbance on soil by the ploughing and refilling.
- Duct without any cable inside will also establish in certain areas. It can be utilized for the future run.

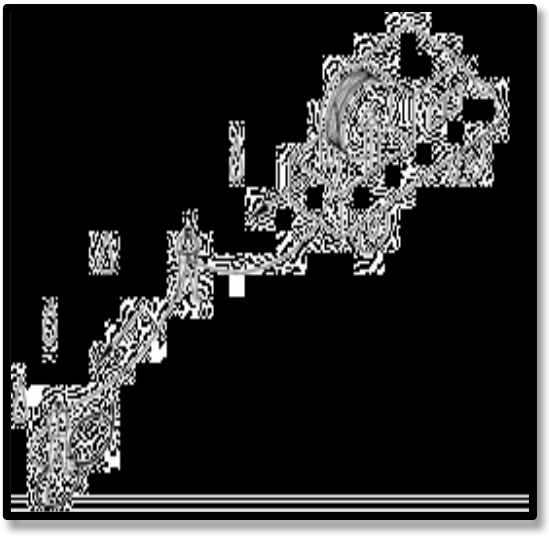
2.4.11.3 Step – Figure 8'ing' (Contd.)

Following steps to be taken for figure 8ing:

- Draw two adjacent circles to create a figure 8 pattern with a diameter of 1.5 to 2 meters.
- If require, use cardboard sheets between layers.
- Create one above other layers of figure 8 loops by taking the cable from drum or payoff trailer and Put it on the circle marks.
- To create figure 8 pattern loop by heavy optical fiber cables, required at least 3 people, one at center and one each on end of both circles.
- Figure 8 pattern is particularly advantages for heavy and lengthy optical fiber pulling in opposite direction.
- Avoid free running and jerking of cable while winging by using cable drum brake



2.4.11.3 (a): Figure



2.4.11.3 (b): Figure

2.4.11.4 Step – Cable Pulling & Blowing

Cable pulling

In many situations where the optical fiber cable is laying in short straight enough paths, without using any sophisticated equipment, the cables can be pulled in by hand. In optical fiber cable the entire load has to be subjected to strengthen members. To make it, at the end of the cable, strengthen member will be tied to the pulling rope and the same has to be attached/clamped with the whole cable units to distribute the force. If it is not connected the entire cable components, there is a chance of elongation of the cable sheaths, and this will result damage on optical fibers inside. There are so many standard equipment are available to apply additional mechanical force to pull. With this equipment there are number of pulling grips available to lock pulling rope with the entire cable units. Pulling grips are tightening around the cable and which will be attached with the pulling to distribute the tensile force.

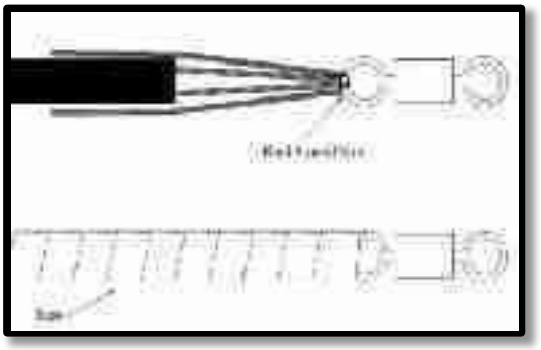
Pulling grip is the attaching point of cable to the pulling rope so to make the attachment in proper way and to avoid the fiber damage at the pulling contact point grip has to be fixed on the aramid strengthen member inside the outer jacket around the core of fiber optic cable. The jacket length which has to be removed will depend on the length of pulling grip. The rope should be attached with core part of the cable with the strengthen member inside cable to avoid the elongation of cable sheath due to heavy tensile force. To fix the rope with core strengthen member a tape or tying mechanism has to utilize. In order to avoid the twisting of fiber, need to use swivel at the joining point of cable and rope. It will avoid the chance of twisting of fiber cable by keep away transferring the twisting motion of pulling rope to cable. The total load which is applied on to the cable has to be measured and analyzed continuously to avoid the excess force acting on the fiber. As per the permissible value of tensile strength of the cable it is better to cut the cable 10 feet from pulling side. It will avoid the generation of large tensile force on cable.

Even if the optical fiber cable is pulled over along the trench length, it is not ready to terminate or connectorization. Before doing any connectorization or termination the cable has to pull over an extra length for the future works on either side of the route ends or in between manholes. In outdoor application the connectorization or the termination work will not take place on the trench end, for this purpose the cable will be laid to a special clean area or a tent. So, the total length should be considered at the time of link design including all extra cable length to the workplace and for the future upgrades.

2.4.11.4 Step – Cable Pulling & Blowing (Contd.)

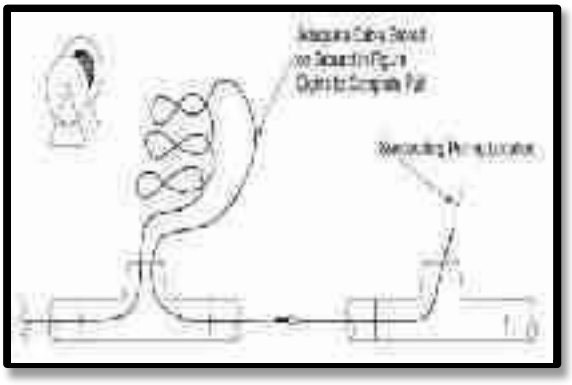
Cable pulling (Contd.):

- OFC's maximum tensile strength varies from 600 pound to less than 1000 pounds; lubricants are used to reduce pulling tension.
- Pulling forced should be kept less than the designated limit.
- At the time of pulling optical fiber cables, especially when using high power equipments are using to pull the tension monitoring equipments should be used. To avoid the twisting in optical fiber swivels should be used when pulling cable. Duct should have pull ropes or tapes to ease future runs.
- During OFC de-spooling avoid– twisting or sharp bending. Pay off cable form the top of the reel during cable pulling.
- If the cable has to lay long distance, pulling should be completed in number of stages at least two. Attach pulling eyed to the cable's strength member.
- Adequate cable is stored on ground in the shape of figure 8. The cable pulling should be started at the middle pulling location and get going towards end.
- Once it reached at one end of the cable run, the same process started at the center again in opposite direction. After the entire pull is complete, Rack the optical fiber cable.
- Maximum pulling speed to be 3 feet / sec if pulling rope is used; it can be tripled for mule tape.

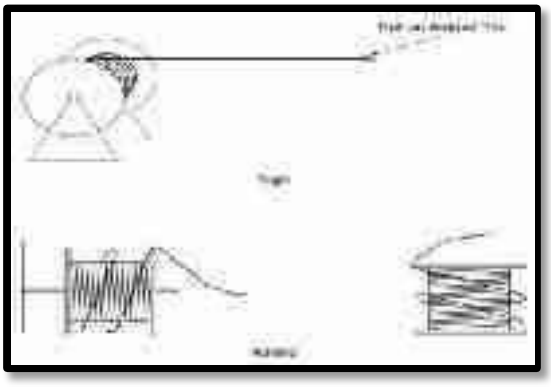


2.4.11.4 (a): Duct with pull ropes, tapes

2.4.11.4 (b): Lubricants for Pulling



2.4.11.4 (c): Adequate cable stored as Figure '8'



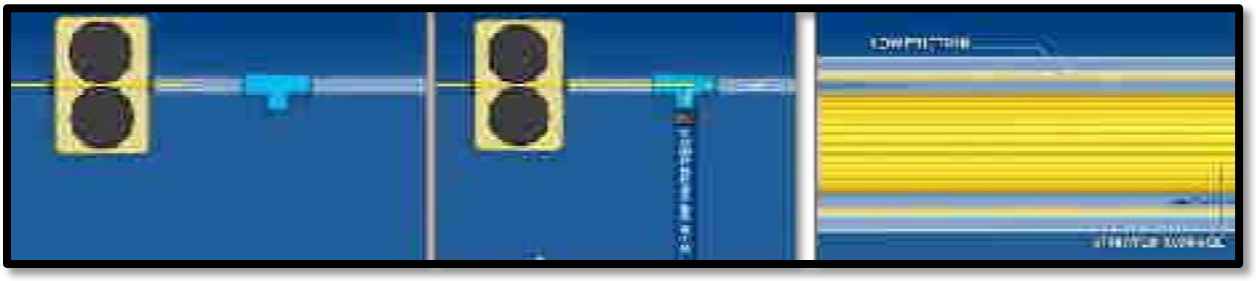
2.4.11.4. (d): Correct way of pulling

2.4.11.4 Step– Cable Pulling & Blowing (Contd.)

Cable Blowing:

Following steps are to be taken for cable blowing:

- Cable is inserted in the motorized blower head with a duct and a one way valve.
- The optical fiber cable will pushed through the duct by using high-speed airflow from a source.
- High speed air current pushes the cable along the length.
- High air drag & low friction causes the cable to move forward.
- It provides high installation speeds, with less cable tension and reduced chances of damage; it requires less manpower



2.4.11.4 (e): Cable blowing

Notes

2.4.11.5 Step – OFC Termination Method

- Put on a fiber boot.

- Measure 14 cm for striping as per specs.

- Strip the fiber using wire stripper.

- Use Alcohol wipes to clean any residue.

- Give the fiber a very slight bend.

- Put the fiber in cleaver holder at 10.5 cm mark (as per specs) and cleave the fiber.

- Put the fiber in the connector & squeeze holder.

- Slide the boot and the connection is complete.

2.4.12 Testing and Closing Activities

After installation, splicing and termination of optical fiber it must be tested for the following:

- Polarity testing
- Total insertion loss
- If there is any problem, troubleshoot it

2.4. 12(a): Testing equipment

- Ensure marking for identification of route for future maintenance and troubleshooting.
- Appropriate cable marking should be done as per the recommended guidelines.
- Backfill and remove debris and rock to clean the site.

2.4.13 Reporting and Documentation

Documentation is absolutely necessary for future references and troubleshooting therefore we should ensure a proper reporting and documentation.

The whole plant of optical fiber cable has to be documented in design part for the installation and future upgradation.

It helps in:

- The loss of time & cost can be reduced by the process planning at the time of installation
- Upgradation process will be more
- The cable laying process will be faster, including cable pulling and installation
- Tracing links & finding faults
- Speed up the pulling process if the routing and terminations are already documented
- The test data should be documented with the previous information to get the acceptance from end user
- After the installation, if there is any repositioning of equipment the documentation will helps to rerouting to the exact end points

Information record about the cable, splice, fiber, paths, etc. is a must and should be captured as follows:

- Cable: manufacturer, type, ID, length, and drum number
- The distance at which the Splices and termination point has done
- Optical fiber type & size, splice and connectors position, losses
- Rote of cable lay
- Optical fiber cable route, loss and test results on cable plant should be noted
- All these data should be kept with the documents of Component, connection, and the test results
- OTDR test results will be stored separately for the troubleshooting purpose in future. It can be printouts or in digital format. The digital data file should be stored in database in an arranged manner to make the troubleshooting easily

2.4.13 Reporting and Documentation (Contd.)

- All the cable spool should be marked with type, installation method has to be followed, total number of fibers inside, and the total length.
- Special requirements should be specified (type of application and installation requirements) to estimate the total manpower and cost required.
- Record test data on each individual fiber run.
- It will reduce the complexity of troubleshooting.
- Documentation will tell you about everything that required for a cable installation, like where cable go, distance between access points, the areas in which where installation take more time etc. Testing information gives the way to find out the degradation over time.

Merely recording is not enough record storage is also an essential ingredient:

- Documentation of data's in plant location is very essential.
- Databases has to be stored in different data formats , paper printouts or digital files, should have multiple copies stored in several locations and make sure that the data is accessible for every teams to review.
- Ensure it is available to all the authorities for review.

Following reports have to be filed regularly so as to regularly update status:

- Report on the status update
- Pending issues
- Challenges
- Faults & Serviceability
- NOC for cable integration
- Final Closure of the job

Exercise

1. Upgradation and troubleshooting will be effective if ---------- has been done in planning.

a. Good workmanship
b. Low loss connectors
c. Safe workplace procedures
d. Proper documentation

2. Installation of OSP cable can be ----------.

a. Pulling in underground in conduit
b. Direct burial
c. Aerial suspension
d. All of the above

3. Which protective gear is essential in optical fiber installation and maintenance operation?

a. Eye protection
b. Plastic apron
c. Gloves
d. Shoe covers

4. What is the use of fiberglass rod inside many fiber optic cables?

a. Increasing the pulling tension
b. Limit bend radius to preventing kinking
c. Winding the fibers around
d. Tying to messenger cables

5. What is the significant of 'figure 8' pattern in optical fiber laying?

a. Keep it from getting tangled with the pull rope
b. Make it easier to spray on lubricant
c. Keep workers from walking on it
d. Prevent it from twisting

Exercise (Cont.)

6. At the time of installation process, the bend radius should be---------- --.

a. times the cable diameter
b. 10 times the cable diameter
c. 20 times the cable diameter
d. 50 times the cable diameter

7. What is the standard depth of trench for the underground duct cables?

a. 3-4 feet (1-1.2 meters)
b. 1-2 feet (0.3-0.5 meter)
c. 6-8 feet (2-2.5 meters)
d. As deep as the local building codes allow

8. Select the correct way of using cable tie

a. Should be tightened firmly to prevent cable movement
b. Can be used to hang cables from J-hooks or cable trays
c. Should be rated for the weight of the cables
d. Can harm cables if too tight, so they should be hand-tightened

9. In the following options, what will decide the speed of direct burial installation?

a. Local permit
b. Ground
c. Cost
d. Cable

10. For immediate testing after splicing which method will utilize?

a. OLTS
b. OTDR
c. VFL
d. CD test set

Exercise (Cont.)

11. Which test method will use for testing splice point in an installed optical link?

a. OLTS
b. OTDR
c. VFL
d. CD test set

12. Select correct option in following, before installing cables in utility poles

a. Look for other installation options
b. Have the power cables shut down
c. Notify the proper authorities
d. Notify the owners of other cables

13. Long cable pulls in conduit may require_____or_____.

a. Heavy-duty mechanical pullers
b. Trucks or tractors to pull the cable
c. Lubricants
d. Intermediate pulls

14. Most fiber optic cables do not have sufficient strength to allow direct aerial installation, but or can be used to install them aerially.

a. Rubber clamps
b. Pole-mounted grips
c. Lashing to another cable
d. Lashing to messenger strands

15. Read the following statement carefully and decide true or false:

One should be able to rely the contractor to not only do the installation but to assist in the design of the network and help choose components and vendors. (True / False)

Exercise (Cont.)

16. What is route inspection?

17. What are benefits of route inspection?

18. Briefly explain the three steps of route inspection.

Exercise (Cont.)

19. What does the fiber optic installer kit comprise of?

20. Which tools are required to complete the most common fiber optic operations?

21. What is the role of a connector curing oven?

Exercise (Cont.)

22. What is an optical fiber?

23. Define tensile strength. What is the reason for not suppressing the tensile strength?

24. What is a short-term load?

25. What is minimum bend radius?

Exercise (Cont.)

26. What is an installation bend radius?

27. What are the do's and don'ts while installing a cable?

28. How is the test procedure conducted?

29. What are the chances of damaging the cables?

30. What are the things that a cable is tested for?

31. What is attenuation?

Exercise (Cont.)

32. What are the reasons for attenuation?

33. What is fiber optics continuity?

34. When is the continuity good?

35. What are the natural factors affecting OFC?

36. What are the man-made factors affecting the OFC?

37. What are mechanical and environmental effects on the choice of cable components?

Exercise (Cont.)

38. Are optical fibers sensitive to damage?

39. How to avoid damages to cables?

40. What is the effect of damages on the cables?

41. What precautions should be taken during cable unloading?

42. How to do the drum inspection?

43. What are the steps involved in the laying of optical fiber cable?

Exercise (Cont.)

44. What is Trenching? List the steps involved.

45. List the precautions to be taken during trenching?

46. What is aerial cable and what are the steps to install the same?

47. What are the steps of installing the duct?

48. What is an inner duct and what is its purpose?

49. What is figure '8ing' and OFC pulling?

Exercise (Cont.)

50. What is cable blowing and what are its steps?

51. List the steps involved in cable termination.

Tips

- Understand the functioning of each tool
- Practice using each tool extensively
- Ask the instructor or fellow trainees in case of ambiguity
- Make sure that you are absolutely thorough with the proper functioning of the tools
  Thoroughly practice the OFC installation process in detail
- For practicing OFC installation process visit a live site and perform each step-in detail under the supervision of your trainer
- Work as a team to perform each step effectively
- Follow the details as mentioned in the workbook Notes

Notes

Skill India
कौशल भारत-कुशल भारत

सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP

N·S·D·C
National
Skill Development
Corporation
Transforming the skill landscape

Telecom
Sector
Skill
Council

3.Perform planned Maintenance and Repair Activities

Unit 3.1 – Carry out testing of optical fiber

Unit 3.2 – Carry out splicing of optical fiber

TEL/N6403

Key learning Outcomes

At the end of this module, you will be able to:

1. Explain and perform tests on OFC for continuity, insertion loss and troubleshooting
2. Explain and perform tests on OFC using optical inspection microscope
3. Explain and perform tests on OFC using OTDR
4. Explain and perform test on OFC using visual fault locator
5. Explain and perform bare fiber testing
6. Describe splicing its purpose and its benefits
7. Describe and demonstrate mechanical and fusion splicing

UNIT 3.1: Testing Optical Fiber Cable

Unit Objectives

At the end of this unit, you will be able to:

1. Explain and outline the reasons for testing optical fiber cable
2. Explain and perform different types of tests – optical microscope inspection
3. Explain and perform tests using visual fault locator
4. Explain and perform bare fiber test using OTDR

3.1.1 Testing Optical Fiber

Testing is employed to gauge the performance of fiber optic elements, cable plants and systems. Testing is use as the parts like fiber, connectors, splices, LED or optical maser sources, detectors and receivers square measure being developed, testing confirms their performance specifications and helps perceive however they're going to work along to judge the performance of fiber optic parts, cable plants and systems. Designers of fiber optic cable plants and networks depend upon these specifications to see if networks can work for the planned applications.

If it's a long outside plant cable with intermediate splices:

1 Verify the individual splices with Associate in Nursing OTDR take a look at conjointly, since that is the only way to ensure that every splice is perfect

2 All fibers during a cable plant ought to be tested a minimum of for continuity, correct finish to finish connections and most significantly loss. However, every of those tests is performed depends on the installation kind, needed standards and also the actual layout of the parts within the cable plant

3 Lots of time and value is saved if the installers and contractor know the correct measurements that require to be created, perceive a way to create those measurements properly, have the correct tools, keep them in shape, have the calibrated device to use them with efficiency

If you are the network user, you need to test:

1 Transmitted and received power, the operation of system can be identified by measuring the power

3.1.1 Testing Optical Fiber (Contd.)

Following basic preparation are essential to conduct testing of optical fiber cable:

1 Before starting, get together all the tools and must be checked weather it is working properly also we should know how to handle & use them

2 Try all the equipment in office and then take them to the field

3 If internal memory is available in your power meter to record data, make certain you recognize a way to use this

4 Make sure every fiber has cable layouts to calculate & test a loss budget you know result expectation. It's difficult to get the work done when you have to contact the manufacturer by your cell phone from the job site

5 Check every one of your reference check jumper cables in each direction, single-ended loss test can be used to confirm they are all correct

6 You can usually customize these reports to your specific requirements - figure all this out before you leave within the field - it might prevent time on installations

7 A fiber tracer higher power version referred as visual fault locator (VFL). Visible laser is used in visual fault locator (VFL) that can also locate faults

8 To test or to trace fibers continuity for longer distance, the red laser light is best option. Red laser light show breaks in fibers, identifies splices in splice trays or high loss connectors

3.1.1.1 Testing Optical Fiber Visual Fault Locator

We start the testing with a visual inspection tool called visual fault locator. This is a very helpful tool to trace a path of a fiber, if the fibers are not broken from one end to another with many connections, duplex connector polarity verifying for example. It looks like a pen-like instrument or a flashlight with a LED or light bulb, source that mates to a fiber optic connector. Connect the fiber to be tested to the visual tracer and check at the other end of the fiber to identify the light transmitted through the core of the fiber. If there's no light at the end, return to intermediate connections to seek out the bad section of the cable.

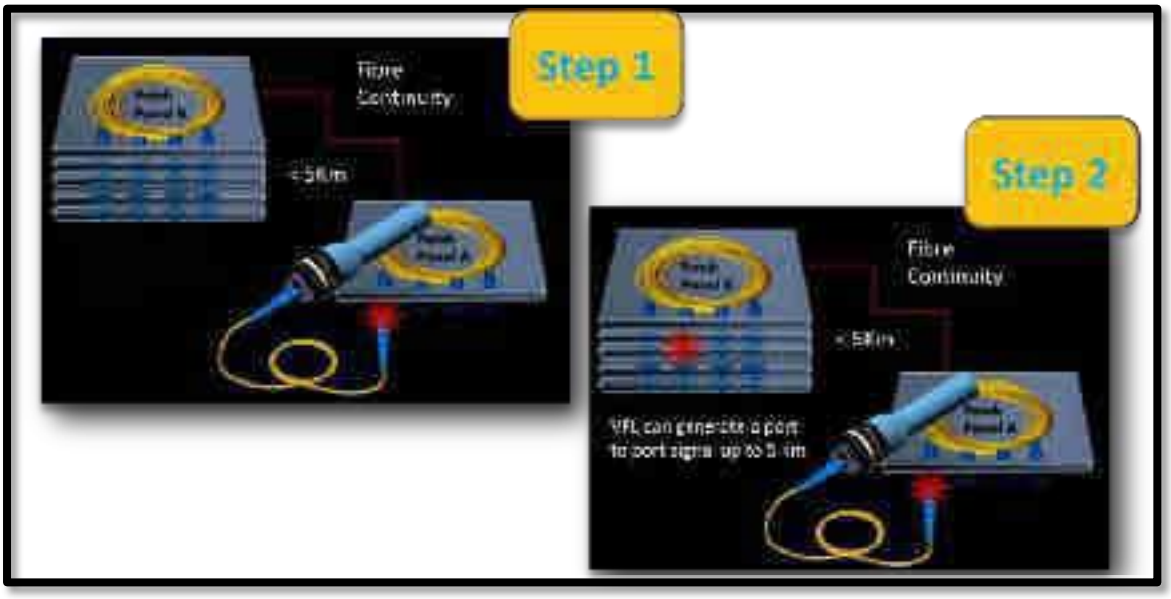
3.1.1.1 (a): Visual fault locator

3.1.1.1 Testing Optical Fiber - Visual Fault Locator (Contd.)

A handheld optical test device is to inject a highly visible laser light into a fiber to identify faults, bends, continuity, or port identification.

3.1.1.1 (b): VFL general specifications

Continuity check with the help of the visual fault locator (VFL):

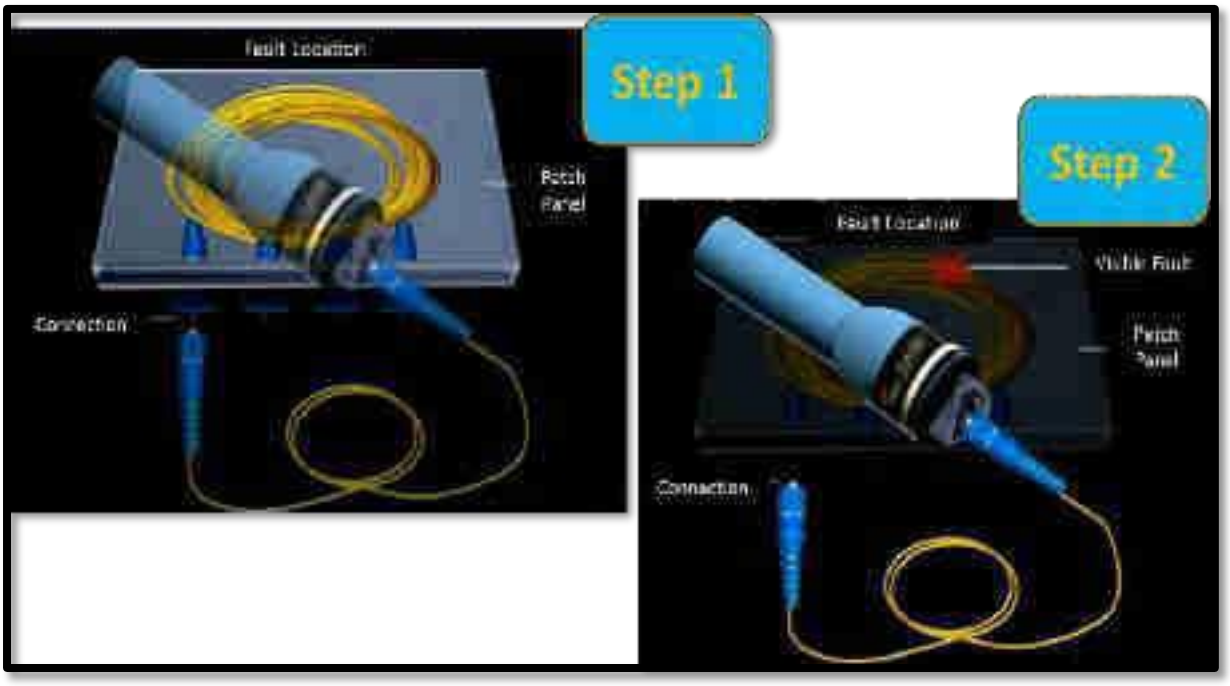


3.1.1.1 (c): Checking continuity through VFL

3.1.1.1 Testing Optical Fiber - Visual Fault Locator (Contd.)

It can be used to identify fault location. A highly visible laser light is injected on to a fiber; for identification of faults, bends, continuity or port identification.

You can easily see the loss of light at fiber damage by the bright red light from the VFL through many yellow or orange simplex jacket cables (except black or grey jackets). It's most important function is finding faults near the connectors or in short cables where OTDRs cannot find them. You can also utilize this gadget to visually test and optimize mechanical splices or pre polished -splice type connectors. By visually reducing the light lost you can get the lowest splice loss. In fact- no ways to think of doing one of those pre polished -splice type connectors. No option will assure you of high yield with such connectors.



3.1.1.1 (d): Testing fault location through VFL

Light Source

In fiber optics, a light source (such as a laser or LED) is used to generate electromagnetic radiation in order to carry out a specific duty, such as identifying link loss or certifying LAN/WANs or detecting faults, breakage, and microbends. For the purpose of testing a fiber optic cable, light is injected into the wire using a fiber light source. Laser diodes and light emitting diodes are the two main types of them. The wavelength they produce and the kind of cable they test help to further distinguish them from one another

Fig. 3.1.1.1 (e)-
Light Source (LED)

Power Meter

The power of fiber optic equipment or the strength of an optical signal transmitted through a fiber cable can be precisely measured using an optical power metre (OPM), a testing tool. It aids in calculating the power loss the optical signal experiences as it travels through the optical media.

An optical time-domain reflectometer (OTDR), on the other hand, provides length and loss by exploiting backscatter reflection, while an optical power metre measures the incoming optical power

A cheap method of certifying optical fiber is with a power metre and light source. These two test tools are used to gauge the optical signal's actual power as well as the fiber optic light's continuity and loss.

Fig 3.1.1.1(f):
Power Meter

Exercise

Fill in the blanks -

1. Optical power meter is used to measure the strength of the _____
2. _____and _____are the two main types of light source for detecting faults
3. _____is a visual inspection tool.
4. OTDR is _____
5. OPM and OTDR is used for measuring the strength of _____

3.1.1.2 Testing OFC – Inspection Microscope

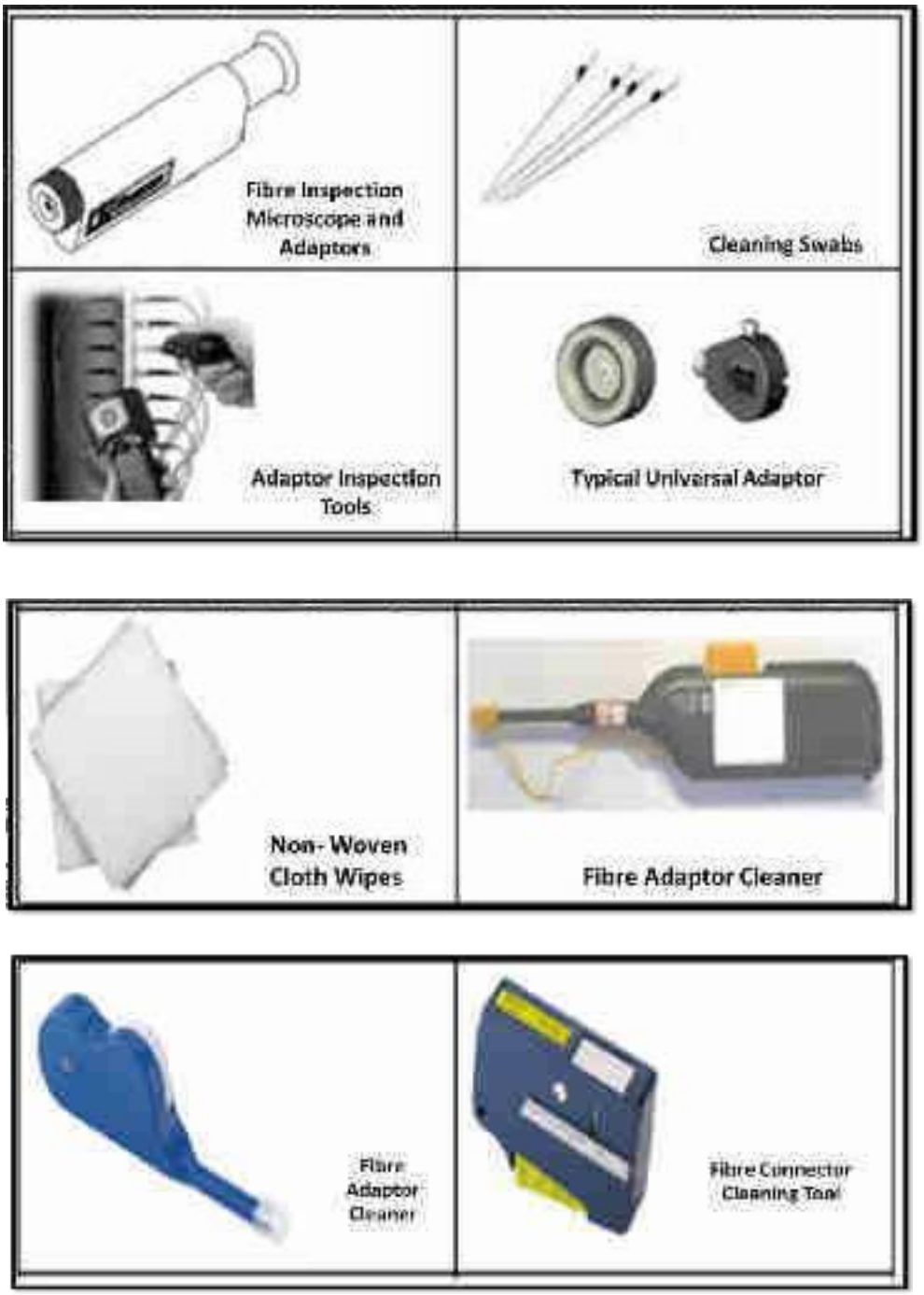
Testing OFC – Inspection Microscope Visual connector inspection with the help of microscope. To inspect connectors fiber optic inspection microscopes are used so as to confirm proper polishing; find problems like scratches, polishing defects and dust and also check termination quality procedure and diagnose problems. A good connector will have a smooth, scratch free, polished finish and the fiber will not show any signs of cracks; chips or areas where the fiber is either protruding from the end or pulling back into it.

1. The amplification for survey connectors can be 30 to 400 power units, however it is best to utilize a medium amplification.
2. The best Microscope instruments enable you to investigate the connector. From a few edges, either by tilting the connector or having point light to get the best picture of what's happening.
3. Check to ensure the magnifying instrument has a simple to-utilize connector to append the connectors important to the microscope.
4. Make sure to watch that no power is available in the link before you take a gander at it in a microscope to secure your eyes. The microscope will focus and concentrate, any power introduce in the fiber, into your eye with possibly dangerous outcomes. A few magnifying instruments have channels which expel infrared light from sources to be protected.

3.1.1.2 (a): Inspection microscope

3.1.1.2 Testing OFC – Inspection Microscope (Contd.)

Following tools are required for 'Visual Connector Inspection':



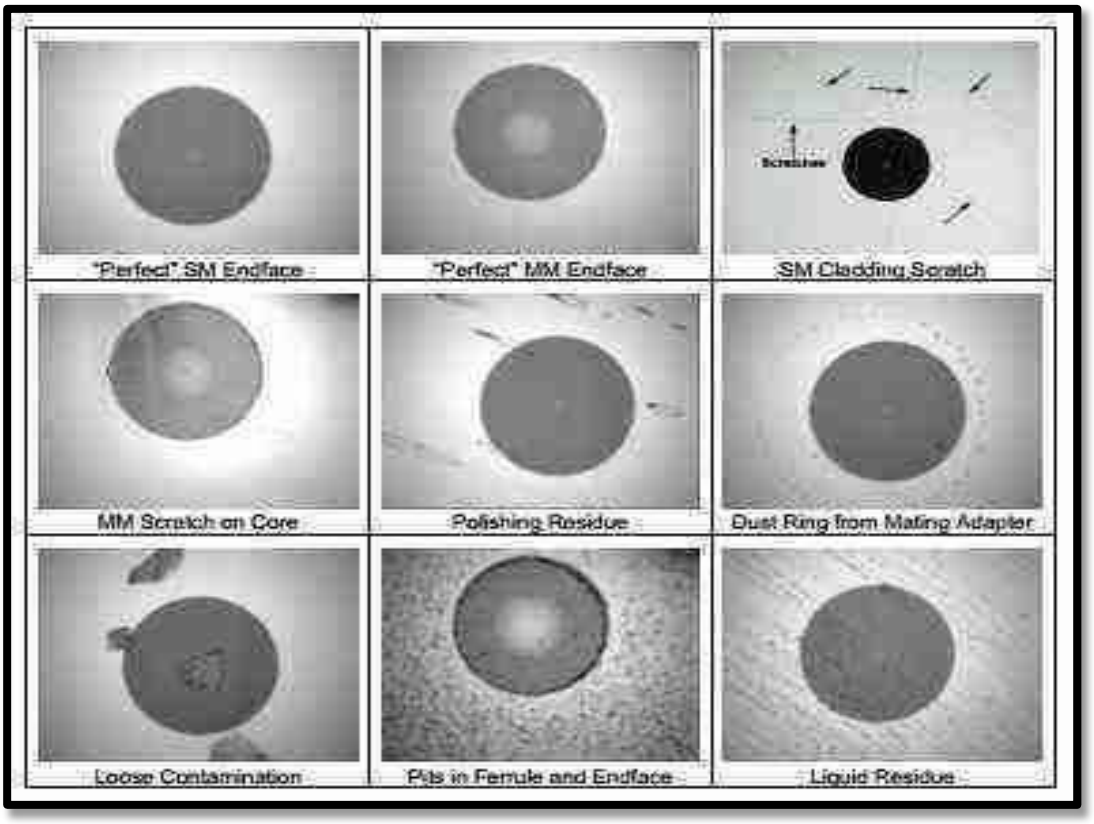
3.1.1.2 (b): Tools required for visual connector inspection

3.1.1.2 Steps - Visual Connector Inspection

Following are the steps to be followed for visual connector inspection:

3.1.1.2 (c): Steps for visual connector inspection

Connector end views as observed by microscope:



3.1.1.2 (d): Connector end views

3.1.1.3 Testing OFC – Connector End Cleaning Procedure

We need to learn the connector end cleaning procedure.

1 Continuously keep clean tops on connectors, bulkhead grafts, fix boards, or anything that will have an association made with it.

2 Utilize build up free cushions and isopropyl liquor to clean the connectors. A few solvents may assault epoxy, so just liquor ought to be utilized. Cotton swabs and material desert strings. Some optical cleaners leave buildups. Buildups as a rule pull in soil and make it stick.

3 All "canned air" now has a fluid force. Quite a while back, you could purchase a jar of plain dry nitrogen to blow things out with, yet not any more. The present airborne cleaners utilize non-CFC force and will leave a buildup unless you hold them at consummate level when splashing. Splash for three to five seconds before utilizing to guarantee that any flui d fuel is ousted from the spout. These jars can be utilized to blow tidy out of bulkheads with a connector in the opposite side or a dynamic gadget mount. Never utilize packed air from a hose (This radiates a fine splash of oil from the compressor or blow on connectors. Try not to utilize your breath, your breath is loaded with moisture, also each one of those germs.)

4 A superior approach to clean these bulkheads is to remove the two connectors and clean with alcohol pads, at that point utilize a swab made of a similar material with liquor on it to wipe out the bulkhead.

5 Indicators on fiber optics control meters should be cleaned with the alcohol pads sometimes to remove dirt. Take the connector off and wipe the surface, at that point air dry.

6 Ferrules on the connectors/links utilized for testing will get messy because they scrap off the material of the arrangement sleeve in the splice bushing. Some of these sleeves are formed glass-filled thermoplastic and sold for multimode applications. These will give you a filthy connector ferrule in 10 inclusions. You can see the front edge of the connector ferrule getting dark. The arrangement sleeve will develop an inner edge and make a hole between the mating ferrules (a 1–2 dB attenuator). Utilize the metal or fired arrangement sleeve bulkheads just in the event that you are expecting rehashed additions. Cleaning the above requires aggressives crubbing on the ferrules with the liquor cushion and hurling the bulkhead away.

7 Few companies sell fiber optics cleaning kit. These are better solutions but perhaps not as cost-effective as making your own to meet your needs.

3.1.1.3 : Connector end cleaning procedure

3.1.1.4 Tools – Bare Fiber Test

- Knife

- Armor stripper

- Kevlar shears

- Alcohol and wipes

- Fiber stripper

- Fiber cleaver

- Bare fiber adapter

- OTDR

- Heat shrink & cable ties

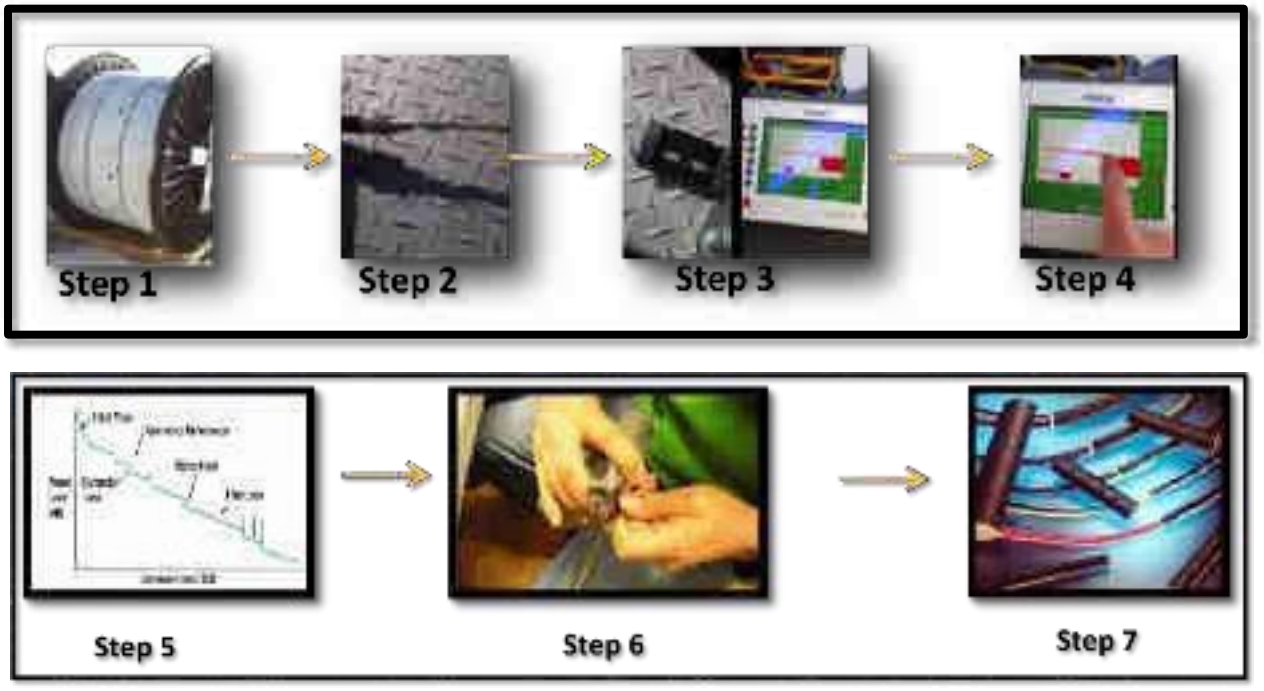
3.1.1.4 Steps Bare Fiber Test (Contd.)

Two reasons we may want to test bare fiber i.e., fiber that has not been terminated in connectors but is simply plain optical fiber:

- To ensure the fiber or cable we make meets its specifications.
- To test cable on the reel to ensure it is in good condition before we install it (or even purchase it or accept it on delivery).

Following steps are needed to perform the tests:

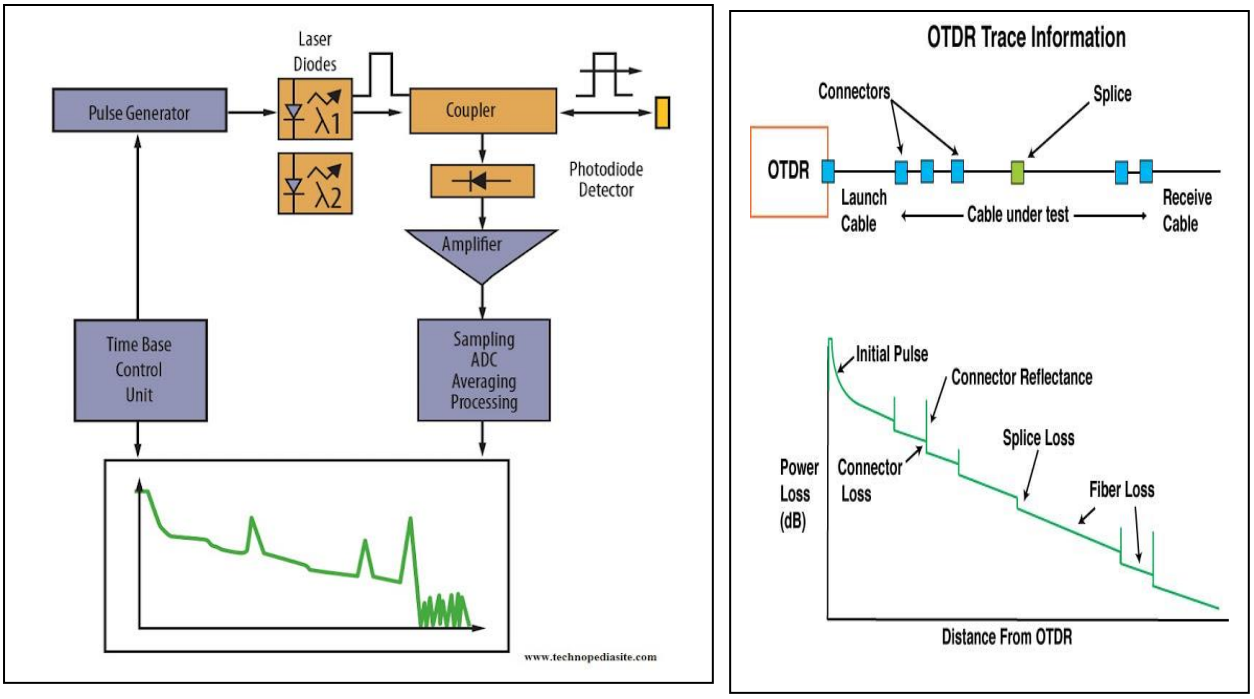
Step 1 – Check the cable and record any visible signs of damages.
Step 2 – Strip cable end at least of 2 ft, strip and clean the fibers.
Step 3 – Connect the fiber using a bare fiber adapter to an OTDR through a patch cord.
Step 4 – Switch on the OTDR and select the proper wavelength and refractive index for the test. Record and print the OTDR traces on disk. Mention direction of measurement and loose tube - fiber color.
Step 5 – Compare the test records to the specifications of manufacturer's
Step 6 – Take out bare fiber adapter and Remove excess fiber from the cable end.
Step 7 – Install heat shrink / protective covering sleeve to the link end to keep the section of dampness or different contaminants.



3.1.1.4 : Steps for bare fiber tests

3.1.1.5 About OTDR

Telecommunication characterization of optical networks can tested by fiber optic tester called OTDR; it acts like a one-dimensional radar system. The use of an OTDR is to detect, locate, and measure elements at any location on a fiber optic cable Only one end access is need by OTDR for the link and acts like a one-dimensional radar system. By providing pictorial trace signatures of the fibers under test, graphical representation also possible in the entire fiber optic link.



3.1.1.5 (a): OTDR block diagram and OTDR trace

3.1.1.5 About OTDR (Cont.)

What an OTDR Measures?

OTDR measures optical distance to:

- Elements: splices, connectors, splitters, multiplexers
- Faults
- End of fiber

OTDR also measures:

- Loss of splices and connectors.
- ORL (optical return loss) of link or section
- Reflectance of connectors
- Total fiber attenuation

Why do I need an OTDR?

Fiber testing is essential to provide confidence that the network is optimized to deliver reliable and robust services without fault.

Telecom, video, and data wireless service providers and network operators want to ensure that their investments into fiber networks are protected. In outside fiber optic plant, each cable will be tested for end-to-end loss and with an OTDR to ensure the installation was properly made. Installers will be asked to use loss test sets (source and power meters) as well as OTDRs, performing bi-directional tests and providing accurate cable documentation to certify their work. Later, OTDRs can be used for troubleshooting problems such as break locations due to dig-ups.

Many contractors and network owners question whether they should perform OTDR testing for premises cabling. They also want to know if OTDR testing could replace the traditional loss testing with a power meter and a light source. Premises fiber networks have tight loss budgets and less room for error. Installers should test the overall loss budget with a light source and power meter (Tier 1 certification required by TIA-568C standards).

OTDR testing (Tier 2 certification) is a best practice that can identify the causes for excess loss and check that splices and connections are within appropriate tolerances. It is also the only way to know the exact location of a fault or a break. Testing a fiber link with an OTDR also helps document the system for future verification.

3.1.1.5 About OTDR (Cont.)

Understanding key OTDR specifications:

Wavelengths

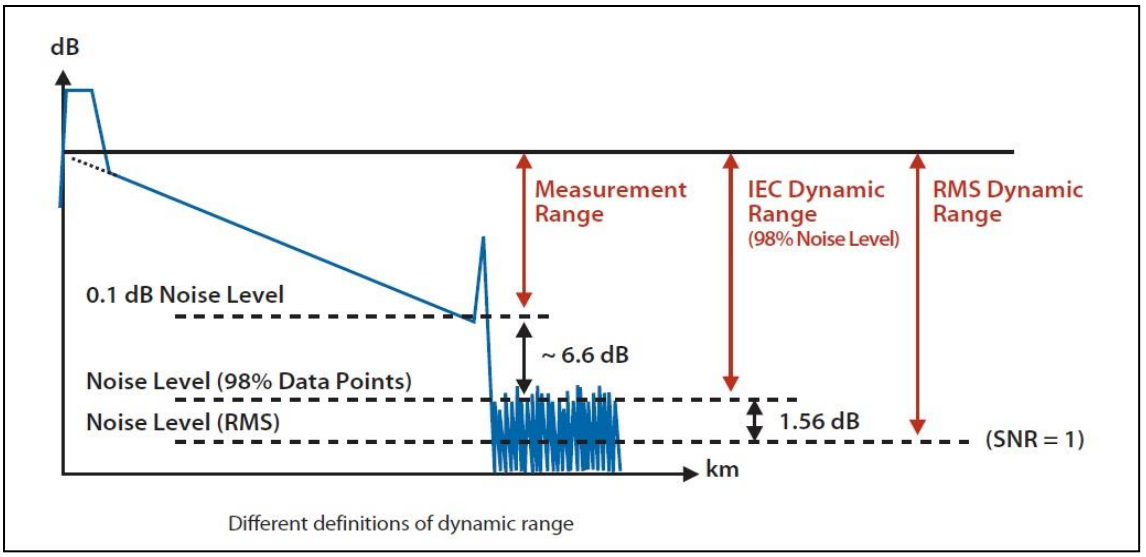
In generic, The same wavelength is used to test the fiber which is used for transmission that is used for transmission

- 850 nm and 1300 nm wavelengths for multimode fiber links.
- 1310 nm and/or 1550 nm and/or 1625 nm wavelengths for single mode fiber links.
- Filtered 1625 nm or 1650 nm for in-service troubleshooting of single mode fiber links.
- CWDM wavelengths (from 1271 nm to 1611 nm with a channel spacing of 20 nm) for commissioning and troubleshooting single-mode fiber links carrying CWDMtransmission.
- 1490 nm wavelength for FTTH systems (optional — test can be performed at 1490 nm, but a common recommendation is to test at 1550 nm to minimize additional investments).

Testing at a single wavelength will only allow fault location. Testing at dual wavelengths is recommended during the installation phase and troubleshooting as it detects fiber bends.

Dynamic Range

The dynamic range is an important characteristic since it determines how far the OTDR can measure. The dynamic range specified by OTDR vendors is achieved at the longest pulse width and is expressed in decibels (dB). The distance range or display range sometimes specified is usually misleading as this represents the maximum distance the OTDR can display, not what it can measure.



3.1.1.5 (b): Key OTDR specification table

3.1.1.5 About OTDR (Cont.)

Dead Zone

Dead zones are important characteristics since they determine the OTDR's ability to detect and measure two closely spaced events on fiber links. Dead zones are specified by OTDR vendors at the shortest pulse width and are expressed in meters (m).

- The event dead zone (EDZ)is the two consecutive reflective events of minimum distance (such as two pairs of connectors) can be distinguished by the OTDR.

- The attenuation dead zone (ADZ) is the minimum distance after a reflective event (for instance, a pair of connectors) that a non-reflective event (for instance, a splice) can be measured.

Pulse Width

The relationship between dynamic range and a dead zone is directly proportional. To test long fibers, more dynamic range is needed so a wide pulse of light is required. As dynamic range increases, the pulse width increases and the dead zone increases (close events won't be detected by the OTDR). For short distances, short pulse widths should be used to reduce the dead zones. The pulse width is specified in nanoseconds (ns) or microseconds (µs).

3.1.1.5 (c): A typical OTDR

3.1.1.5 About OTDR (Cont.)

Choose your OTDR as per your applications:

Wide range of OTDR models available in the market, addressing different measurement needs and test. A solid understanding of key OTDR specifications as well as the application will useful for buyers make right choice for their specific needs.

These are the questions to answer before looking for an OTDR:

- Which kind of networks will you be testing? LAN, metro, long haul?
- Which type of fiber will you be testing? Multimode or single-mode?
- What is the maximum distance you could test? 500 m, 20 km, 125 km?
- Which kind of measurements will you perform? Construction (acceptance testing), troubleshooting, in-service?

Premises, LAN/WAN, Data Centers, Enterprise

Type of Fiber	Multimode	Single-mode	Single-mode and Multimode
Wavelengths	850/1300 nm	1310/1550 nm	850/1300/ 1310/1550 nm
Key specifications	Shortest possible dead zones to locate and characterize events that are closely spaced		

FTTA, DAS, and Cloud RAN

Type of Fiber	Multimode	Single-mode	Single-mode and Multimode
Wavelengths	850/1300 nm	1310/1550 nm	850/1300/ 1310/1550 nm
Key specifications	Shortest possible dead zones to locate and characterize events that are closely spaced		

Point-to-Point Access/Backhaul

Type of Fiber	Single-mode
Wavelengths	1310/1550 nm
Key specifications	Dynamic range ≤35 dB at 1550 nm
	Shortest possible dead zones to locate and characterize events that are closely spaced

CWDM & DWDM

Type of Test	Installation, Wavelength Provisioning, or Troubleshooting
CWDM Wavelengths	From 1271 nm to 1611 nm with a channel spacing of 20 nm
DWDM Wavelengths	C-band tuning – C62 to C12 (1527.99nm –1567.95nm)
Key specifications	Dynamic range ≥35 dB to test through mux, optical add/drop multiplexer (OADM), and demux
	Shortest possible dead zones to locate and characterize events that are closely spaced
	Integrated continuous-wave light source capability to verify end-to-end continuity

Metro/Long/Ultra Long Haul

Type of Network	Metropolitan/ Long Haul	Very Long Haul	Ultra Long Haul
Wavelengths	1310/1550/ 1625 nm	1310/1550/ 1625 nm	1550nm/ 1625 nm
Key specifications	Dynamic range ≥40 dB at 1550 nm	Dynamic range ≥45 dB at 1550 nm	Dynamic range ≥50 dB
	Shortest possible dead zones to locate and characterize events that are closely spaced		

Fig. 3.1.1.5 (d): Choosing OTDR as per application

3.1.1.5 About OTDR (Cont.)

Choose your OTDR asper your applications.

Point-to-Multipoint Access/FTTH/PON

Type of Test	Installation — Before and After Splitter(s)	Installation with one or cascaded Splitter(s)	In-Service Trouble-shooting
Wavelengths	1310/1550 nm	1310/1550 nm	Filtered 1625 nm or 1650 nm
Key specifications	Dynamic range ≤35 dB at 1550 nm	Dynamic range ≥35 dB at 1550 nm to test through 1/32 splitter type	Dynamic range not relevant
		Dynamic range ≥40 dB at 1550 nm to test fibers with 1/64 splitter type	
	Shortest possible dead zones to locate and characterize events that are closely spaced	Shortest possible PON/splitter dead zones + automatic multi-pulses acquisition	Shortest possible dead zones to locate and characterize events that are closely spaced + automatic multi-pulses acquisition

Multiple Applications

Type of Network	Premises/Access	Metro to Very Long Haul
Wavelengths	850/1300/1310/1550 nm (1625 nm optional)	1310/1550/1625 nm (adding an external filter on the 1625 nm wavelength makes OTDR suitable for FTTH/PON network troubleshooting)
Key specifications	Dynamic range: Not relevant for multimode; ≤35 dB at 1550 nm for single-mode	Highest dynamic range
	Shortest possible dead zones	
	Modular platform that evolves according to testing needs and provides the most flexibility	

Fig. 3.1.1.5 (e): Choosing OTDR as per application

Fig. 3.1.1.5(f) : Various OTDR

3.1.1.5 About OTDR (Cont.)

Other Important Product Specifications

Operating an OTDR is not difficult, but it does require familiarity with fiber testing best practices in order to measure correctly. OTDR traces can only be analyzed and correctly interpreted by trained and experienced technicians. It's difficult for a less-qualified technician to operate an OTDR and make sense out of the results.

An intelligent software application, integrated into the instrument, can help technicians use an OTDR more effectively, without the need to understand or interpret OTDR traces. It schematically shows the fiber link tested and automatically recognizes and interprets each OTDR event and represents it as a simple icon for easy understanding. However, it is mandatory to be able to correlate the results to the original OTDR trace if needed.

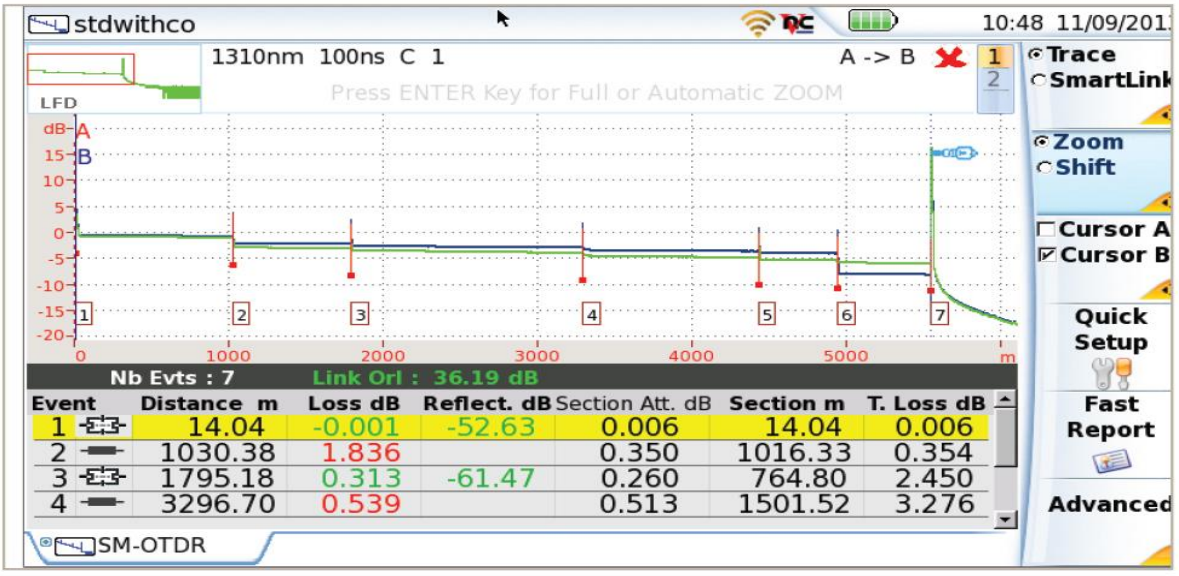


Fig. 3.1.1.5 (g): OTDR trace

3.1.1.5 About OTDR (Cont.)

Factors to consider when choosing an OTDR include:

- **Size and Weight**: vital on the off chance that you need to scale a cell tower or work inside a building.
- **Show Size**: 5" ought to be the base prerequisite for a show estimate. OTDRs with littler showcases cost less yet make OTDR follow examination more troublesome.
- **Battery Life**: an OTDR ought to be usable for a day in the field; 8 hours ought to be the base.
- **Follow or results stockpiling**: 128 MB ought to be the base inward memory with alternatives for outside capacity, for example, outer USB memory sticks.
- **Bluetooth and additionally Wi-Fi Wireless Technology**: remote network empowers effortlessly sending out test results to PCs/portable workstations/tablets.
- **Measured quality/Upgradability**: a particular/upgradable stage wills all the more effortlessly coordinate the development of your test needs; this may be costlier at the season of procurement yet is more affordable in the long haul.
- **Post-Processing Software Availability**: in spite of the fact that it is conceivable to alter and record your strands from the test instrument, it is significantly less demanding and more advantageous to examine and archive test comes about utilizing post-handling programming.

Fig. 3.1.1.5 (g): OTDR

3.1.1.5 About OTDR (Cont.)

Acceptance testing of fiber optic cable with the help of OTDR

Fiber optic acceptance testing guarantees that any new link coordinates the optical and physical necessities of the arranged application. This testing ought to be endless supply of the link, preceding its establishment.

Always carefully examine the cable reel for physical signs of shipping damage. Look for evidenc e that indicates the cable has been subject to unacceptable amounts of stress. The reel will include some form of cable documentation. A copy of this information should be attached to the acceptance test form. These documents generally contain traceability information, as well as optical test data difficult to acquire in the field. For example, a multimode fiber reel's documentation would include information on the fiber's bandwidth, while a single-mode fiber reel would provide test data related to the various types of optical dispersion.

This documentation form also lists the fiber's index of refraction, as documented by the fiber's manufacturer. This number should not be used for the index of refraction in the OTDR because it does not include the cable's helix factor, which is a measure of the difference in fiber versus cable sheath length. The technician must compensate for the extra fiber slack by adjusting the OTDR's refractive index setting so that OTDR distance readings match the sequential markings on the cable jacket. The test of acceptance is the best opportunity to make these adjustments prior to cable installation. One important consideration in testing is to ensure a good launch condition that couples the maximum amount of light from the OTDR into the fiber. Poor launch conditions result in greatly reduced distance to measurement capability, and possible measurement errors. Before any tests can be made with the OTDR, it must be properly terminated to the fiber to be tested. For installed spans, linking the OTDR to the span under test requires a hybrid patch cord. Most OTDRs have an internal ultra-physical contact (UPC) spherical polish, but some reflection-sensitive systems use the angled physical contact (APC) polish. The hybrid patch cord addresses both connector type and connector polish issues. Always clean the end face of the plug prior to mating to the OTDR.

There are two strategies for ending a fiber. The primary technique utilizes an exposed fiber connector, which comprises of an attachment body that holds the fiber to be tried. The outline of the exposed fiber connector is with the end goal that the fiber can go totally through the connector body and harm the optical port. Along these lines, the exposed fiber connector should never be associated straightforwardly to the OTDR. Rather, the connector ought to be utilized with a short fix rope and mating connector sleeve to disconnect harm from OTDR's port.

3.1.1.5 About OTDR (Cont.)

The second technique utilizes a ponytail with a reusable mechanical graft, which enables simple mating of the filaments to be tried with the OTDR. The Norland reusable mechanical graft has been utilized for a considerable length of time for testing exposed strands. It highlights a glass body that inside holds and adjusts two filaments. The join is loaded with a refractive list coordinating liquid to decrease reflections.

To make the association, strip and sever both strands to be tried, at that point embed and focus both into the mechanical join to finish the end. For the link to be tried, set up the finish of the link by stripping ceaselessly the external coats, reinforcement (if present), and cradle tubes to a separation of roughly one meter. Clean the greater part of the strands and sort out them considering the business standard shading code. Strip, clean, and separate the principal test fiber and embed it into the other side of the mechanical join

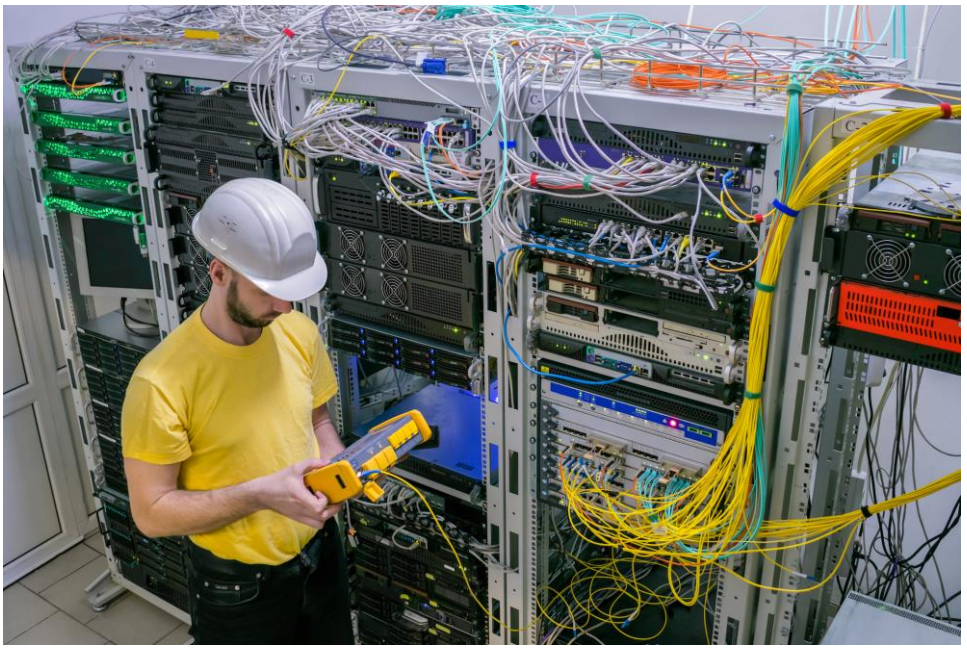


Fig 3.1.1.5 (h): Technician performing OTDR test

3.1.1.5 About OTDR (Cont.)

We will utilize the manual technique for OTDR operation. Begin the OTDR and select the right wavelength and refractive list for the test. Set the OTDR's estimation mode to "Two Point Attenuation". In this mode, the OTDR enables you to set markers at any two focuses on the backscatter follow and show the constriction of the locale between the markers in either dB or dB per kilometre. For an acknowledgment test, set the primary marker toward the start of the follow the underlying tail of the no man's land and the second marker toward the finish of the follow. The outcomes will show as dB/km at a wavelength being tried. Set the OTDR to "Constant Mode" and alter its range, beat width, and zoom settings so the whole fiber traverse is noticeable on the screen.

For this situation, alter the filaments in the brief mechanical graft. Make certain that the divide length is right and that the filaments are focused in the join.

In real-time mode, the trace may appear noisy. Start the OTDR's averaging mode to reduce noise and clean up the trace. After averaging is complete, the event table will show reflective events at the OTDR port and at the end of the fiber. The trace should appear linear with no abrupt interruptions that would indicate a break or other fault in the fiber. After the dead zone, the straight line will have a very gentle slope indicating the attenuation of the fiber span.

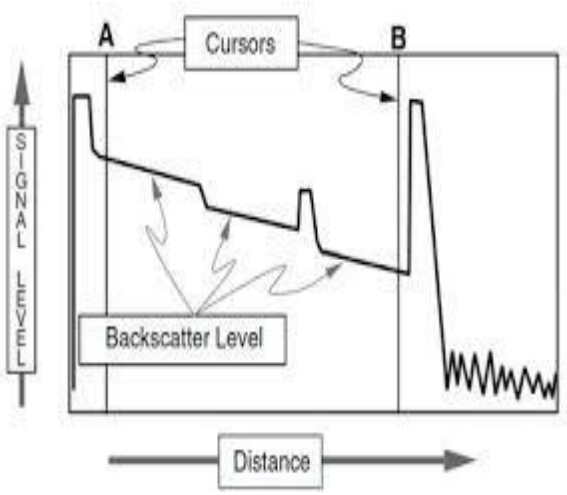


Fig 3.1.1.5 (i): An OTDR trace showing a linear attenuation

3.1.1.5 About OTDR (Cont.)

Marker placement is extremely important when making any OTDR measurement. Select the "A" marker and use the arrow keys to place it immediately following the dead zone at the OTDR's connector. The tail of the dead zone is shaped somewhat like a ski slope. The exact point where this slope becomes a straight line is the point where the marker will be placed. The far Fiber end could be a spike representation, or less commonly, by a roll-off. In either case, the "B" marker must be placed at the exact point where the backscatter trace ceases to be a straight line. To correctly place the second marker, use the zoom controls on the OTDR for increased resolution.

The OTDR will display the distance from the OTDR connector to the end of the fiber as well as the complete loss of span in dB or the loss per kilometer. Use data storage features of the OTDR to save the trace using a unique file name. If using a dead-zone box, the length must be subtracted from the length measurement. When measuring the other fibers in the cable, the end reflection should be located at the roughly same point. The presence of shorter fibers implies that the fiber is damaged or stressed within the cable structure and will require further investigation. It could also be caused by cable structures with inner and outer rows of buffer tubes. The inner buffer tubes would have a shorter fiber length than those in the outer rows. In this case, an index of refraction adjustment must be made for both inner and outer rows and the adjustment documented.

For each fiber, make a note of the total length and dB per kilometer for each test wavelength on the acceptance test form. It is also important to test each fiber at the wavelengths designed for the fiber type. For multimode fiber, this is 850 and 1300 nanometers, and for single-mode fibers, both 1310 and 1550 nanometers. Refer to the testing specifications and note if they pass or fail. In addit ion, make note of the sequential markings at both ends of the cable, as well as the adjusted value of refractive index.

After each fiber has been tested, trim back 50 percent of the exposed length. This indicates that it has been tested, but allows re-testing if necessary. When all fibers go under testing, fibre traces must be counted in the OTDR's memory to ensure that all fibers have been documented. Then, cut back the left over lengths of showcased fiber and correctly reseal the cable ends. All users will depend on the OTDR's automatic measurement functions which displays length, losses and reflection values for the fiber span very quickly. In case of an acceptance test, the key points to document are the total length of the fiber, the total loss of the fiber in dB, and the loss of the span for each test wavelength in dB per kilometer.

3.1.1.5 About OTDR (Cont.)

OTDR best practices

Several best practices ensure reliable OTDR testing.

Use of Launch/Receive Cables

Launch and get cables, which has spools of fiber with specific distances, must be connected to it ends of the fiber link under test to qualify the front end and the far end connectors using an OTDR. The length of the launch and receive cables depends on the link being tested, but it's generally between 300 m and 500 m for multimode testing and between 1000 m and 2000 m for single-mode testing. For very long haul, 4000 m of cable may be used. The fiber length highly depends on the OTDR attenuation dead zone, which is function of the pulse width. The larger the pulse width, the longer the launch cable and receive cables. Launch/receive cables must be of the same type as the fiber under test.

Proactive Connector Inspection

A single dirty fiber connection can affect overall signal performance. Proactively inspecting each fiber connection with a fiber microscope probe will significantly reduce network down time and troubleshooting. Always use it in practice to ensure fiber end terminals are clean before making connections. A dirty OTDR port or a dirty launch/receive cable connector will impact the OTDR measurement. It needs to be inspected and cleaned before the launch cable is connected

An optimized fiber optic network's infrastructure delivers reliable and robust services to customers. Positive customer experience drives loyalty, enabling a fast return on investment and sustained profitability. An OTDR is a key field tester for maintaining and troubleshooting fiber optic infrastructures. Before finalizing an OTDR, relook into the applications that the instrument will be utilized and check the OTDR's specifications to ensure that they are suited to your applications.

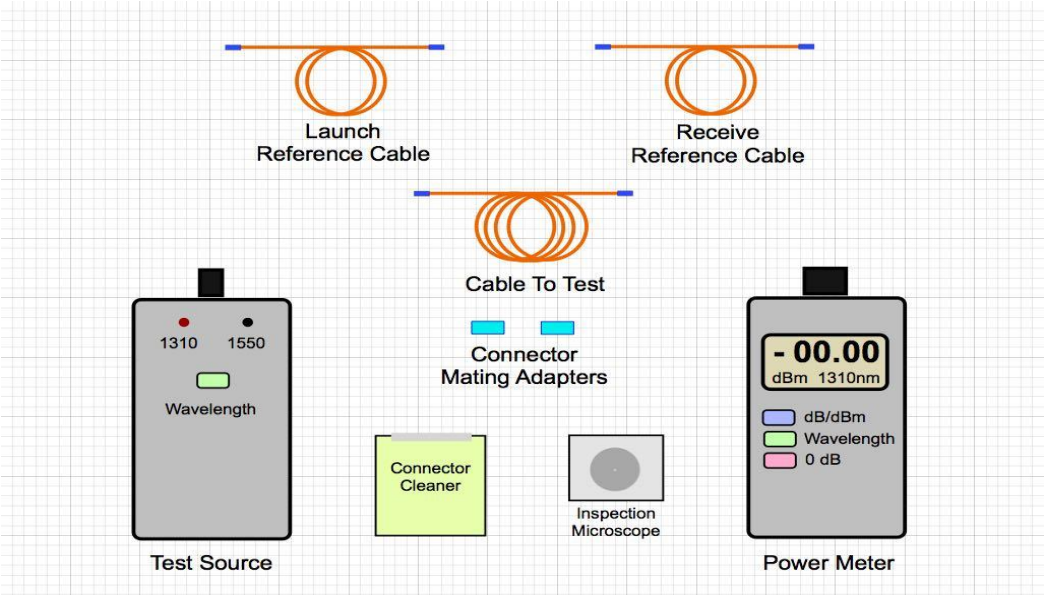
3.1.1.6 – Insertion Loss Test

All measurement in fiber optics brings notice to optical power measured in dB. The power output of a transmitter or the input to receiver is "absolute" optical power measurements, that is, you measure the actual value of the power. Loss is a "relative" power measurement, the difference between the power coupled into a component like a cable, splice or a connector and the power that is transmitted through it. This difference in power level before and after the component is what we call optical loss and defines the performance of a cable, connector, splice, etc.

Insertion Loss Test: An insertion loss verification conducted by light source and power meter is a easy test that resembles the principle of fiber optic link operation. A light is kept on one terminal of the cable and a power meter measures loss at end terminal, as like a link transmitter and receiver use the fiber for communications

3.1.1.6 Tools – Insertion Loss Test (Contd.)

Following are the tools required for measuring 'Insertion Loss':



3.1.1.6: Tools for testing insertion loss

3.1.1.6 Steps - Insertion Loss Test (Contd.)

Following are steps to test the insertion loss:

Step 1 - Connector end-faces are to be verified and cleaned (alcohol wipes) before mating via adapters

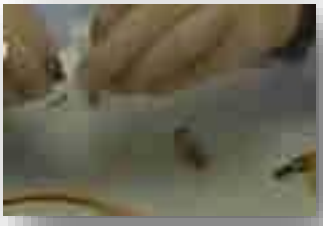
Step 2 - Set-up light source, power meter e.g., adapters, power supply, data entry, etc.

Note: given list of entities need warm up period to stabilize.

Step 3 - Setup "launch cable" for calibration before actual tests.

Step 4 - Connect actual leads to the "launch cable" in order check loss at one end.

Step 5 - Connect the third lead to the "launch cable" and the actual lead to check the loss at the other end.



Step 1

Step 2

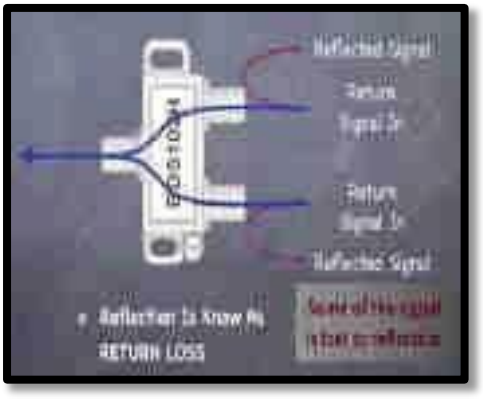
Step 3

Step 4

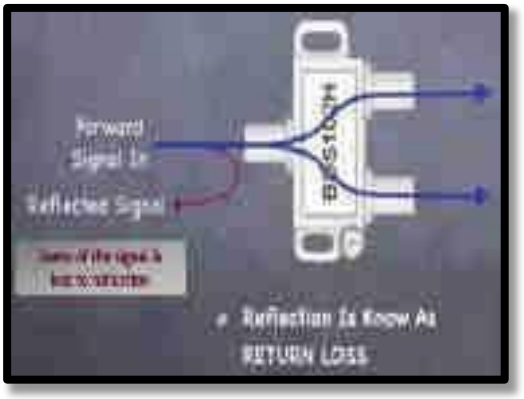
Step 5

3.1.1.7 – Optical Return Loss

Reflectance or optical return loss (also called "back reflection") of a connection is the amount of light that is reflected back up the fiber toward the source, by light reflections off the interface of the polished end surface of the mated connectors and air. It is also called Fresnel reflection and is caused by the light going through the change in index of refraction at the interface between the fiber (n=~1.5) and air (n=~1). Reflectance is primarily a problem with connectors but may also affect mechanical splices which contain an index matching gel to prevent reflectance.



3.1.1.7 (a): Return



3.1.1.7 (b): Return loss

3.1.1.7 Steps – Optical Return Loss Test (Contd.)

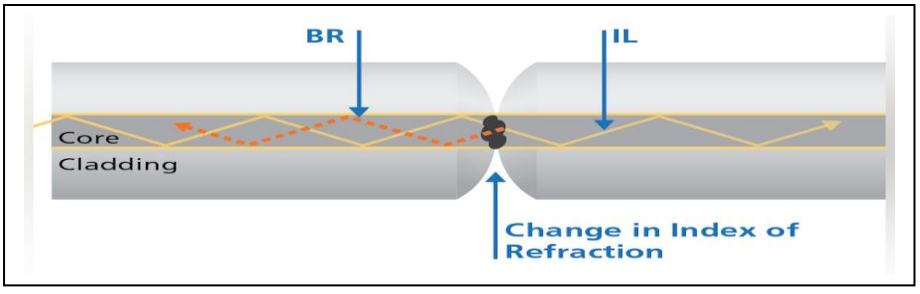
Following are steps to test the insertion loss:

Step 1- Optical Reference Loss (ORL); referencing: count the output power level at the fiber jumper with help of power meter

Step 2- Measure the ORL of the front connector (jumper to test equipment connection). Requires use of connectors

Step 3 - Connect to the fiber under test:

- ORL is measured in dB and is a positive value.
- Higher the number, smaller the reflection – yielding the desired result.
- ORL is most commonly measured at 1310, 1550 and 1625nm single-mode wavelength.



3.1.1.7 : Optical return loss test

3.1.1.8 Miscellaneous Test

Following are the other checks that should be done:

- Verify the fiber joint by OTDR to assured conformance to design needs.
- Sealing off joint closure via heat shrinking/ multi-diameter seals/ mechanical seals as appropriate.
- FRP - Fiber Reinforced Plastic is utilized to strengthen the joint as needed.
- Verify the fiber at both terminals for instances of cross fiber using power source and power meter tests and ensure their elimination

We need to make sure that:

- Joint is kept properly in chamber properly
- Additional cable (loop) is coiled as needed & kept inside the joint
- Sand is filled in the chamber to the brim and the chamber covers are placed properly Connected indicator must be placed right 1 m behind the chamber location (away from road)
- A specific color used for painting indicator (for e.g., yellow for joint)

Notes

UNIT 3.2: Optical Fiber Splicing

Unit Objectives

At the end of this unit, you will be able to:

1. Explain and outline optical fiber splicing
2. Explain and outline the reasons for splicing
3. Explain and outline types of optical fiber splicing
4. Explain and perform mechanical as well as fusion splicing
5. Describe and demonstrate effective safety norms during splicing

3.2.1 Optical Fiber Splicing

Optical fiber splicing:

1 Process of the joining of two pieces of optical fibers. They are of the following two types: mechanical and fusion splicing.

2 Splicing: process of the permanent connection of two pieces of optical fibers.

3 Splicer: device (mechanical) for connecting couple of (minimum 2) two pieces of paper or film or magnetic tape Splice. Joint made by overlapping two ends and joining them.

4 Splices prepare a permanent connectivity between two fibers, as result its use become limited to areas where cables are not ideally available for servicing in the near time

5 Concatenating is used usually to connect /join cables. Normally at outside area cable lines which involve long length (couple of cables connected together).

6 verities of cables are joined be used to couple cables for instant we can consider connecting 48 fiber cable to six 8 fiber cables layer to multiple locations.

7 Usually Splicing is applied to terminate single mode fibers. Splicing is done for pre-terminated fiber ends onto each fiber. Splicing is also applied for OSP restoration.

8 In long run cable laying over long distance Splicing become normal routine in the laying process. In applications other than long distance cabling, most cables are pulled in (one piece) and directly terminated.

9 Requirement Splicing raises in case long cable runs for one straight pull or you need to make cable combination of different types (like bringing a 48-fiber cable in and splicing it to six 8 fiber cables).

10 Usually, one often applies splices for restoring OSP, once the outside plant cable is resolved. a dig-up and cut off a buried cable, usually referred to as "backhoe fade" for obvious reasons.

3.2.2 Reasons for Optical Fiber Splicing

Following are the reasons for carrying out 'Splicing':

1 When we want to deploy a fiber for long, in market manufactured length of cable may not be as per requirement, instead one may need to join fiber pieces. Hence, we need to splice cables together to establish single link of communication.

2 Few times, optical fiber links found cut off, in this case also we need to perform splicing to bring them together. You require splicing for connecting the optical fiber cables to network entities like switches, fiber switches & patch panels, routers (terminating an optical fiber cable directly to a switch not possible)

3 We require to first terminating it to a fiber patch panel which has pigtail connectors, then use fiber patch cords of the right type (SC/LC, etc.) to connect the fiber patch panel and the network/ fiber switch. On newer switches LC-SC patch cords are used - LC at the switch side and SC at the fiber patch panel side.

3.2.3 Types of Optical Fiber Splicing

Types of fiber splicing is as follows:

- Mechanical splicing
- Fusion splicing

Following are the differences between mechanical and fusion

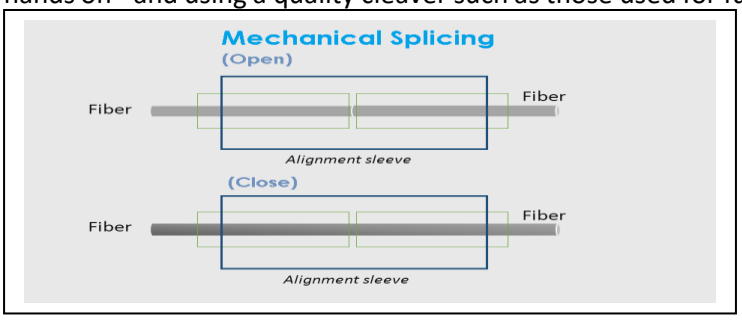
Mechanical splicing	Fusion splicing
Reflection losses (-45 db to -55 db)	No reflection losses
Insertion loss (0.2 db)	Very low insertion loss - (0.1 db to .15 db)
Costs – high	Comparatively less

3.2.3: Difference between mechanical and fusion splicing

3.2.3 Types of Optical Fiber Splicing (Contd.)

Mechanical Splicing

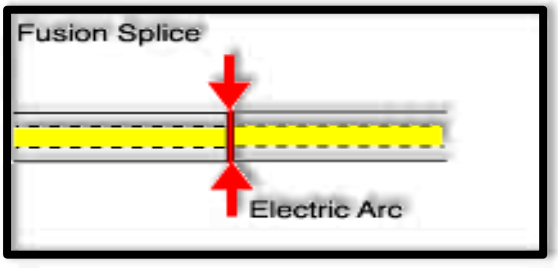
- Mechanical splicing is highly applied for time being restoration and for multimode splicing. Refer below snap.
- Mechanical splices are alignment fixtures that hold the ends of two fibers together with some index matching gel or glue between them. There are many varieties of mechanical splices, like little glass tubes or V-shaped metal clamps. The tools to, but the even though splices are more expensive, the tools to make mechanical splices come with low cost. Restoration is done by multiple mechanical splices, which could work well with both single mode and multimode fiber, by continuous hands on - and using a quality cleaver such as those used for fusion splicing.



3.2.3 (a): Mechanical splicing

Fusion Splicing

- Fusing the two fibers using heat.
- Flame heating sources - micro-plasma burners, oxy-hydric micro-burners, electric arc
- Consistent and easily controlled heat with adaptability.
- Fusion splicing is highly broadly used as it gives for the least loss and lowest reflectance, as well as providing the stiff and best of most reliable joint. 2 Types of Fusion splicing machines are available, a single fiber or a ribbon of 12 fibers at one time. Virtually many single mode splices produced by fusion.
- The most widely using splicing method is fusion splicing because of its advantages over other conventional methods like mechanical splicing. Fusion splicing will provide low loss, low reflectance and most reliable splicing points. Fusion splicing machines are available in two variants. One is for individual fiber splicing and other for 12 fiber ribbon in a single shot.
- The mechanical splicing methods are not using in industrial operations because of its high loss and less durability. Mechanical splicing was used mostly for multimode and in temporary restoration works. Figure below shows fusion splicing machine



3.2.3 (b): Fusion splicing

3.2.4.1 Cable Preparation for Splicing

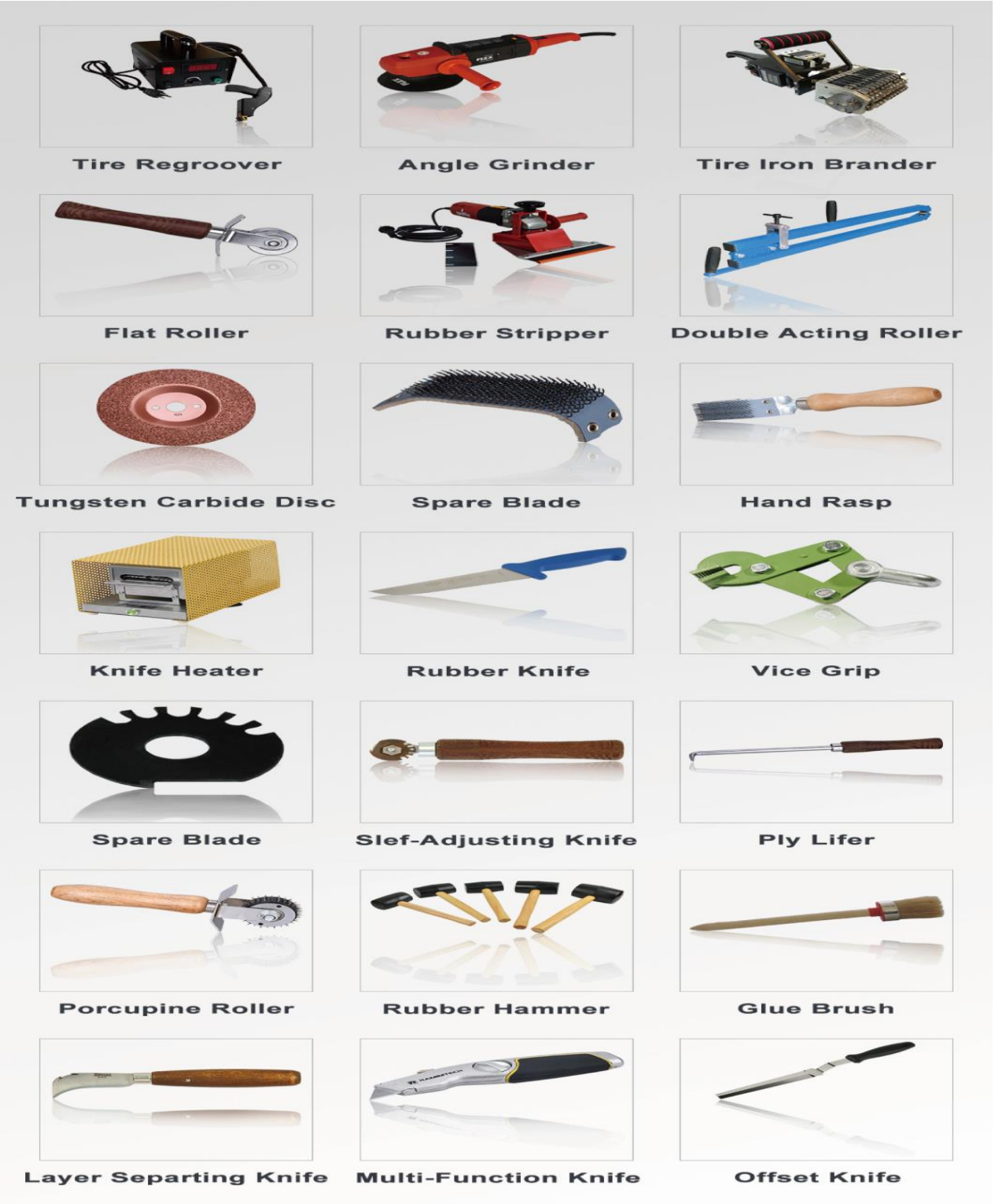
Following should be checks to prepare OFC for splicing:

- Check and verify the installed fiber optic system as per the guidelines.
- Ensure there are no damages on optical fiber. Sheath damages can be located by visually inspect cable.
- Make sure that, the minimum bend radius is maintained along the length as per specs.

3.2.4: Preparing cable for splicing

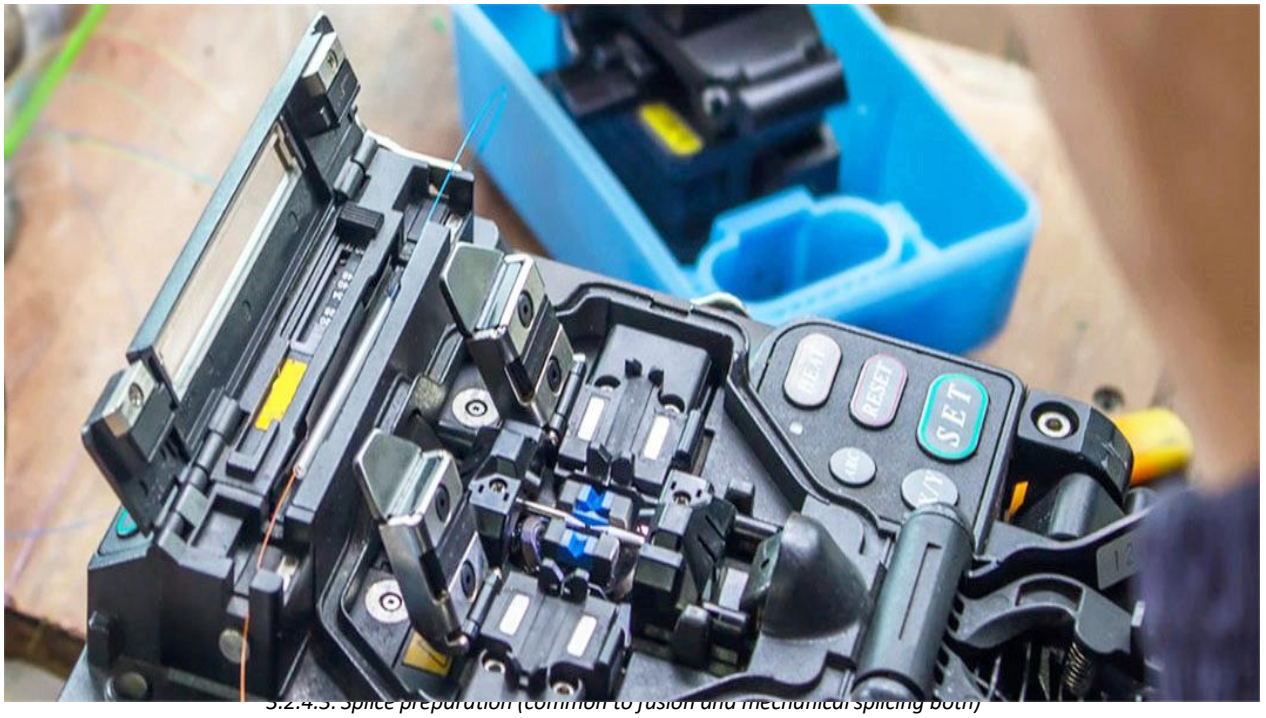
Notes

3.2.4.2 Material and Equipment Used for Splicing



3.2.4.3 Steps – Fusion Splicing Preparation

*** Splice preparation as a step is common to both mechanical and fusion splicing**



3.2.4.3: Splice preparation (common to fusion and mechanical splicing both)

Steps for Fusion Splice

Step 1: Fiber preparation. Fibers are prepared by stripping away all the protective coatings, such as cladding, jacket and sheath. Once only bare glass remains, the fibers are carefully cleaned--and here, cleanliness is next to godliness.

Step 2: Cleaving. Cleaving isn't cutting. As the word implies, it's scoring the fiber using a cleaver and pulling or flexing it until it breaks. The cleaved end must be mirror-smooth and perpendicular to the fiber axis to obtain a proper splice.

Step 3: Fusing the fibers. Fusion, in turn, consists of two steps: aligning and heating. Alignment can be fixed or three-dimensional, manual or automatic, and is normally accomplished with the aid of a viewer that magnifies or enhances the images of the fiber ends, so that they can be properly positioned. Common magnifying devices are video cameras, viewing scopes and optical power meters. Aligning the fibers means perfectly matching up their two ends, so that light can pass from one fiber to the other with a minimum of loss, reflection or distortion. Once the fibers are aligned, they are fused or burned together by generating a high-voltage electric arc that melts the fiber tips, which are then pushed or fed together.

Step 4: Protecting the fiber. Protecting the fiber from bending and tensile forces will ensure the splice not break during normal handling. A typical fusion splice has a tensile strength between 0.5 and 1.5 lbs and will not break during normal handling but it still requires protection from excessive bending and pulling forces. Using heat shrink tubing, silicone gel and/or mechanical crimp protectors will keep the splice protected from outside elements and breakage

3.2.4.4 Steps – Mechanical Splicing

As previously mentioned, the differences between the two lie in the last two steps. Thus, the step 3 and step 4 for mechanical splices are described below.

Step 1 and 2: see the process for fusion splice.

Step 3: Mechanically join the fibers. There is no heat used in this method. Simply position the fiber ends together inside the mechanical splice unit. The index matching gel inside the mechanical splice apparatus will help couple the light from one fiber end to the other. Older apparatus will have an epoxy rather than the index matching gel holding the cores together.

Step 4: Protect the fiber. The completed mechanical splice provides its own protection for the splice.

Notes

3.2.4.5 – Protection

Protection is common to both mechanical and fusion splicing. Protection sleeves provide physical protection to the splice point and an extra protection is given by splice trays.
It serves the following purpose:

- Protects and organize optical fibers neatly
- Protect the fiber from being damaged by bending over minimum bend radii.
- Used in long distance applications.

All the splice trays are enclosed within splice enclosures. There are more than about thousand number types of splice enclosures available in market. In each enclosure there should be multiple numbers of trays stacked like CD tracks. Some enclosures are used for confining series of cable joints of same type of fibers spliced together. Some enclosures are designed to distribute the cables from a larger cable to small individual connections. Closures can be utilized for mid-span access where most of the cables sheath should be striped but most of the buffer will be untouched without opening. Some tubes will be spliced to distribution fibers.

Some of the enclosures may have one side cable entry and some have cables cable entries on both ends. There are different types of splice enclosures available according to the applications where we are using it- buried, mounted on walls, hung from cables or poles. Every application has a special and unique closure. Special type of hardware tools may be necessary for working on different cable or splice, so ensure that you have the right hardware before using the enclosure.

At every splice enclosure, if there is any metallic strengthen member, messenger wire or metallic armor inside, these should be properly grounded. To avoid the force on fiber inside the enclosures, Care should be taken when arranging fibers and splices in trays. A special care has to be given for arranging optical fibers inside trays. The manufactures instruction will help to avoid the damages during twisting and turning of fibers.

Splice point inside the enclosed protected from any other impurities from outside by sealing it properly. From the entrance of closure to the trays, OSP cable will have the tube extenders.
After splicing point on either side there should be almost 1 meter sheath removed optical fiber inside the tray track. By sealing the enclosure, the moisture content entry also can be prevented.

3.2.5 Splicing Safety – Norms and Rules

During splicing following safety rules must be followed:

- Safety glasses must be worn always during the fiber optic lab exercises or when termination or splicing work is performed on a fiber cable. The biggest hazard when working with fiber optics are small, sharp shards of the fiber produced when stripping or cleaving the cable.
- If you notice at any time a classmate or instructor not wearing safety glasses in the area where fiber is being cut, stripped, or cleaved you must immediately tell the person to put on their glasses.
- Be very careful when disposing of fiber ends. Use a disposable fiber trash bin (fiber disposal unit =FDU) to hold small bits of glass until they can be properly disposed of in the trash. For safety, remember to cover the holes on top of the FDU before storing your bin (unit) in your tool kits (box).
- If you don't have a FDU to use when working in some environments, then carefully make a container, like a half empty water bottle or soda can for usage. This helps to prevent accidents. Make sure that the FDU is marked to prevent accidents.
- The optical fiber creates slivers or shards that can easily cause injury to the eyes or create glass splinters in fingers or hands that are difficult to remove from skin, which can become infected if not completely removed. Develop the habit of picking up scraps from the work surface and the floor too.
- Scotch tape can be used to pick up small shards of fiber. Fold the scotch tape around the glass shards before disposing in the trash can.
- Black Paper or other dark colored paper or fabric can be used to give a dark colored working surface. This helps in making the fiber more visible when working with it. It has the side benefit of allowing the fiber cores to be more easily seen, especially when you have a run- away shard.
- When doing fiber work epoxy, anaerobic adhesive, and isopropyl alcohol will be used. The isopropyl alcohol is flammable. Take extra care when handling these substances. It is best to develop the habit of watching for bits of epoxy on your tools or work surface and cleaning it with the alcohol. Develop the habit of wiping all tools frequently with a fiber free cloth and alcohol.
- Keep in mind that epoxy is not removable from clothing.
- Do not touch bare fibers with fingers. The oil from your skin can weaken the fiber over time. It tends to make the glass fiber brittle.
- Terminators removed from the curing ovens will be extremely hot. Use caution when touching hot terminators. Small amounts of alcohol on a fiber free wipe may be used to help cool the terminator more quickly.
- After the terminator is removed from the oven, take great care to ensure the glass rod does not break, pierce the skin, or get into either your eyes or that of any other person.

Exercise

1. At what stage the cable plant loss should be calculated?

a. Design
b. Installation
c. Testing
d. Troubleshooting

2. What is the name of instrument using for the insertion loss?

a. OLTS orlight source and power meter
b. VFL
c. OTDR
d. None of the above

3. What is the type of optical source used to test single mode fibers?

a. LED
b. VCSEL
c. Laser
d. All of the above

4. What is the selection criterion of reference cable in testing?

a. Fiber size and type
b. Fiber size and connector type
c. Connector type
d. Fiber size and loss specification

5. What is the working principle of OTDR?

a. Power meters and sources
b. Radar
c. Mirrors
d. Lenses

Exercise Cont.

6. Which device is using to seal the duct end?

a. Jumpers
b. Protection sleeve
c. Seal plug

7. Which method is providing best splice point?

a. Mechanical splicing
b. Fusion splicing
c. Adhesive/polish connectors
d. Factory terminations

8. Select the correct option given below

a. Connectors are smaller than splices
b. Connectors are demountable, while splices are permanent
c. Connectors require adhesives
d. Splices need expensive tools

9. Which testing method can be used measure individual splice loss in a link?

a. OTDR testing
b. Insertion loss testing
c. Visual fault location
d. Visual inspection

10. Choose the true statements

a. Leaving the proper length of buffer tubes from the cable entrance in the closure to the splice tray
b. Leaving the proper length of fiber to splice and fit the splice in the splice tray
c. Securing the cable properly at the closure entrance
d. Careful cleaning of all fibers

Exercise Cont.

11. What are the various tests conducted once the fiber optic cables are installed?

12. How to make sure each splice is good?

13. As a network user what are the tests which are essential to check the quality of the network?

Exercise Cont.

14. List the names of the testing tools and equipment.

15. List basic preparations related to tools that you would do for an error free testing.

16. What is a VFL and what tests can be conducted by using it?

17. List the general specifications of a VFL.

18. List the two tests that can be conducted using VFL.

Exercise Cont.

19. Explain how visual connecter inspection is done with help of a microscope?

20. List the tools required for a visual connecter inspection.

21. List the steps for conducting visual connector inspection.

22. List the steps for connector end cleaning procedure.

Exercise Cont.

23. Explain how visual connector inspection is done with help of a microscope?

24. List the tools required for a visual connector inspection.

25. List the reasons for conducting a bare fiber test.

26. List the tools required for a bare fiber test.

27. List the steps involved in a bare fiber test.

28. List the difference between 'absolute' and 'relative measurements'

Exercise Cont.

29. What are the tools required for an insertion loss test?

30. What are the steps involved in insertion loss test?

31. What is an 'optical return loss' and what are the steps to measure the same?

32. What is a 'Splice Loss' and how is it measured?

33. Explain the functioning of an OTDR.

Exercise Cont.

34. What is splicing?

35. What are the types of splicing?

36. List the difference between mechanical splicing and fusion splicing.

37. List the steps required for preparing the cable for 'splicing'.

38. List the steps required for mechanical splicing.

Exercise Cont.

39. List the steps required for fusion splicing.

40. List the materials and tools required for splicing.

Tips

Following is recommended tips:

- The recommended steps while testing should be followed as per the book
- The recommended steps in splicing both fusion and mechanical should be followed as per the book
- Follow the health and safety instructions strictly
- Practice thoroughly each of the steps in groups under the supervision of your instructor
- Make sure that each one of you follows the recommended guidelines to avoid damage to material equipment and also to avoid accidents.

Notes

Notes

Skill India
कौशल भारत-कुशल भारत

सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP

N·S·D·C
National
Skill Development
Corporation
Transforming the skill landscape

Telecom
Sector
Skill
Council

4. Perform Corrective Maintenance Activities

Unit 4.1 – Fault notification

Unit 4.2 – Fault localization and restoration

Unit 4.3 – Preventive and corrective maintenance

TEL/N6404

Key learning Outcomes

At the end of this module, you will be able to:

1. Explain, outline and demonstrate NOC fault notification process
2. Define the outline and demonstrate NOC fault notifications process
3. Demonstrate effective response to faults received from customer and contractor
4. Describe with demonstration and monitor steps to fault localization and rectification
5. Explain and outline typical faults and demonstrate problem identification process
6. Perform effective optical fiber restoration process
7. Describe and demonstrate various work instructions

UNIT 4.1: Fault Notification

Unit Objectives

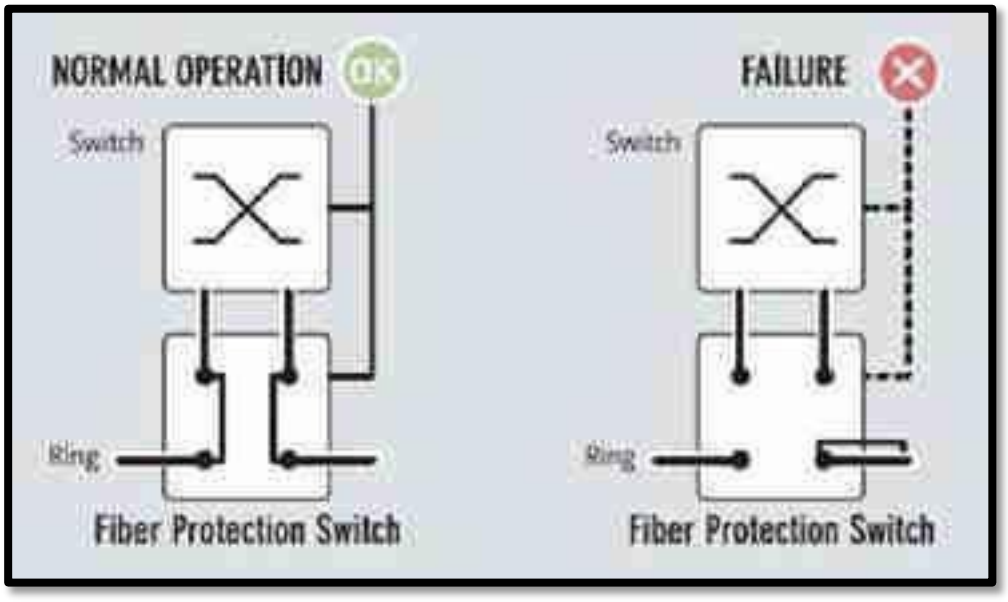
At the end of this unit, you will be able to:

1. Describe fault notification
2. Describe and demonstrate the process of receiving fault notification at NOC
3. Describe and demonstrate fault notification process

4.1.1 Fault Notification

Fault notifications are:

- Intimations received about fault in link, cable ends, connectors or tools & equipment from the customers, contractor or NOC (Network Operations Centre) are relayed to the network operations maintenance team and the same is rectified and the information is relayed back.
- The following picture indicates normal operation and what happens in case of a fault.



4.1.1: Normal operation and failure

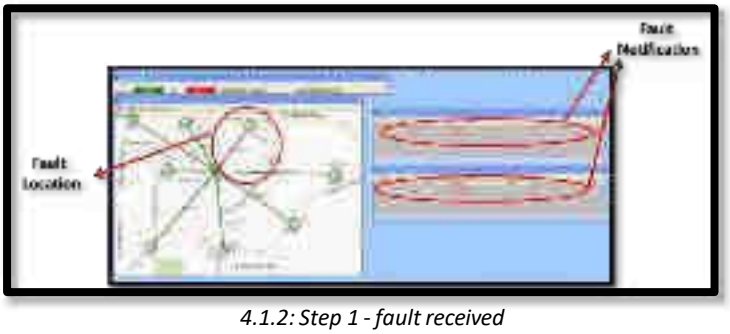
4.1.2 Steps Process of Receiving Fault Notification

A network operations center views the process of receiving the fault from the customer, contractor and the steps are as follows:

Step 1 - An operator zooms in from a macro view to the area of concern. Transceiver detects a fiber fault between a hub and one of the points (sometimes called a spoke).

Step 2 -The operator is immediately notified about the fault's approximate location as depicted in 'Red'. Operator acknowledges the fault and relays information to the network operations team of the area.

Step 3 -Once the fault has been fixed, information from the 'Network Team' is relayed back to the operator who then closes the issue.



4.1.2: Step 1 - fault received

4.1.2: Step 2 - fault acknowledged

4.1.2: Step 3 - fault cleared

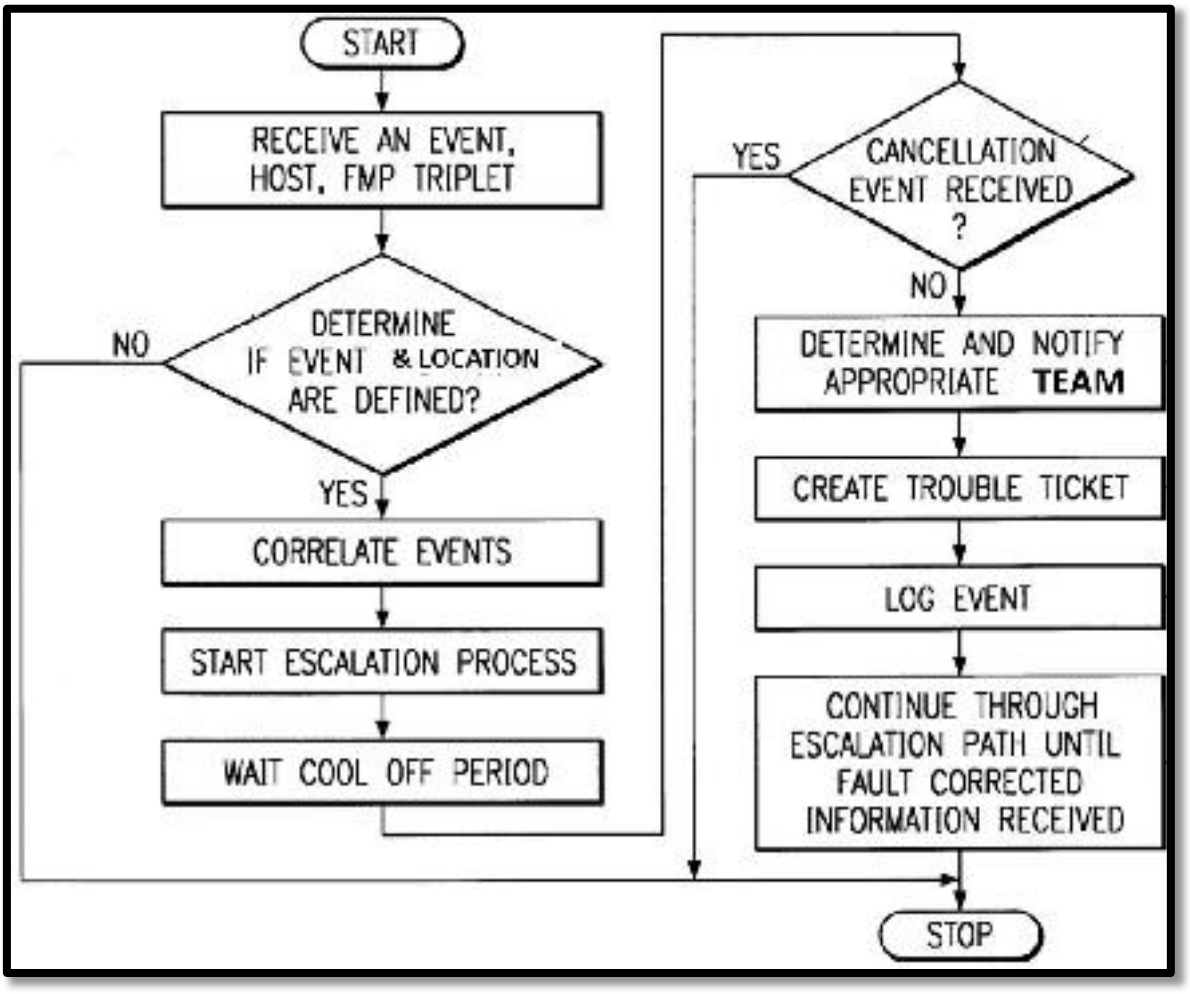
4.1.3 Fault Notification Guidelines

One should adhere to the following guidelines:

- Cross check the fault.
- Confirm the SLA's/ timelines.
- Set the priority with the team members.
- Get in touch with all stakeholders involved in fault rectification.
- Arrange for permits or approvals and equipment if needed.
- Document - fault, reasons and report; document resolution.

4.1.4 Fault Notification Process

One should adhere to the following fault notification process:



4.1.4 Fault notification process

UNIT 4.2: Fault Localization and Restoration

Unit Objectives

At the end of this unit, you will be able to:

1. Define the outline fault localization and rectification
2. Explain, outline, and follow the steps related to fault localization and rectification
3. Explain and outline typical cable system faults
4. Explain the outline, and follow problem identification flowchart
5. Prepare for fault localization and restoration
6. Describe and demonstrate OFC restoration process
7. Describe and demonstrate various work instructions

4.2.1 Fault Localization and Restoration

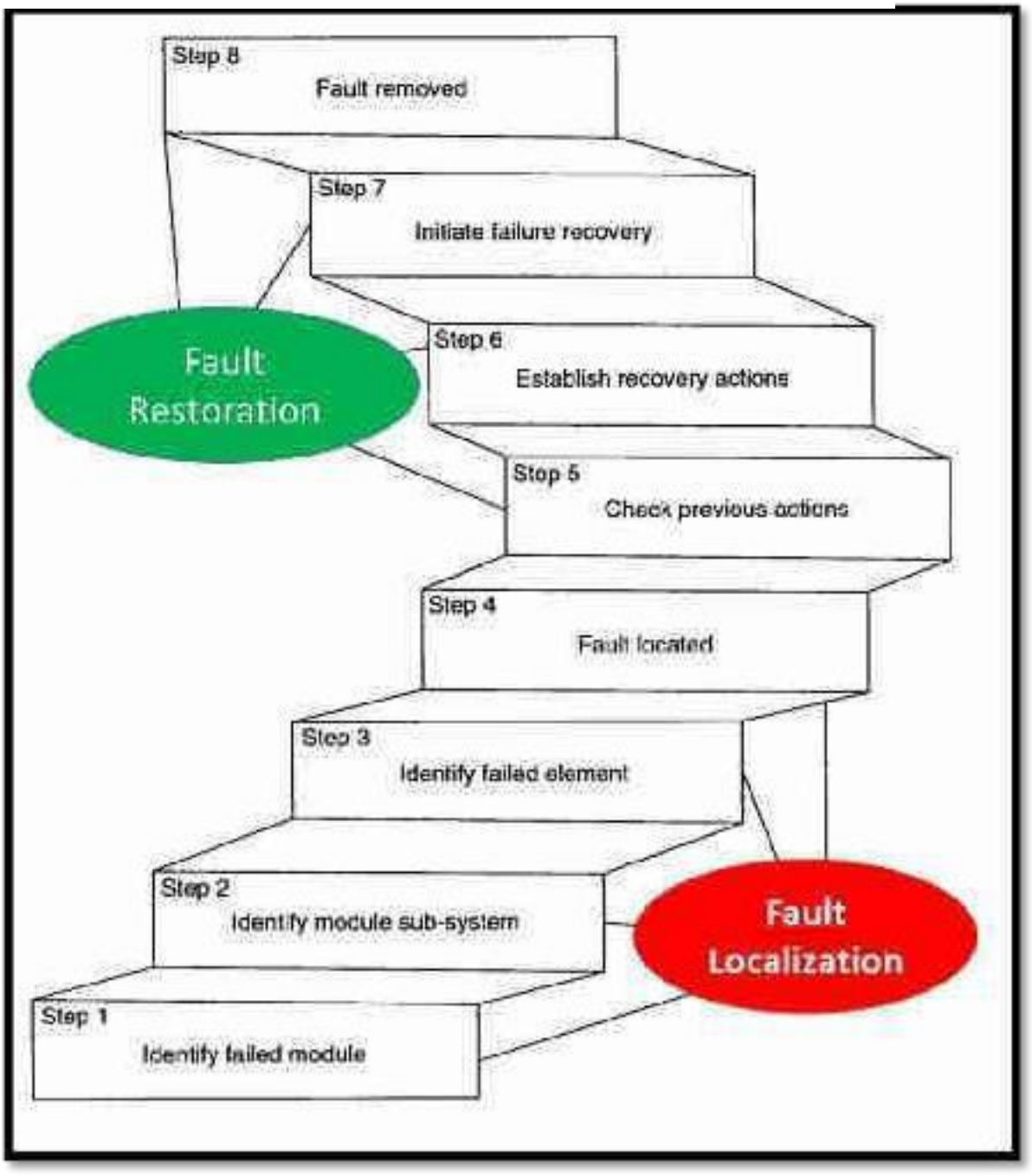
Fault localization and restoration:

To obtain best result from optical fiber, it would be essential to find out and make user adoptable and solve the fiber failures within allowed repair time. The methodology applied to find out and localize the failures of fiber is termed as localization. Merely detecting and locating the fault is not enough and hence the next step is to rectify the fault and close, this is known as rectification.

4.2.1: Fault localization and restoration

4.2.1 Steps - Fault Localization and Restoration

Fault localization and restoration steps:



4.2.1: Fault restoration steps

4.2.2 Cable System Faults

There are various cable system faults which must be rectified. The various faults , the root cause, equipment required for rectification and the remedy is depicted concisely in the following table:

Typical Cable System Faults

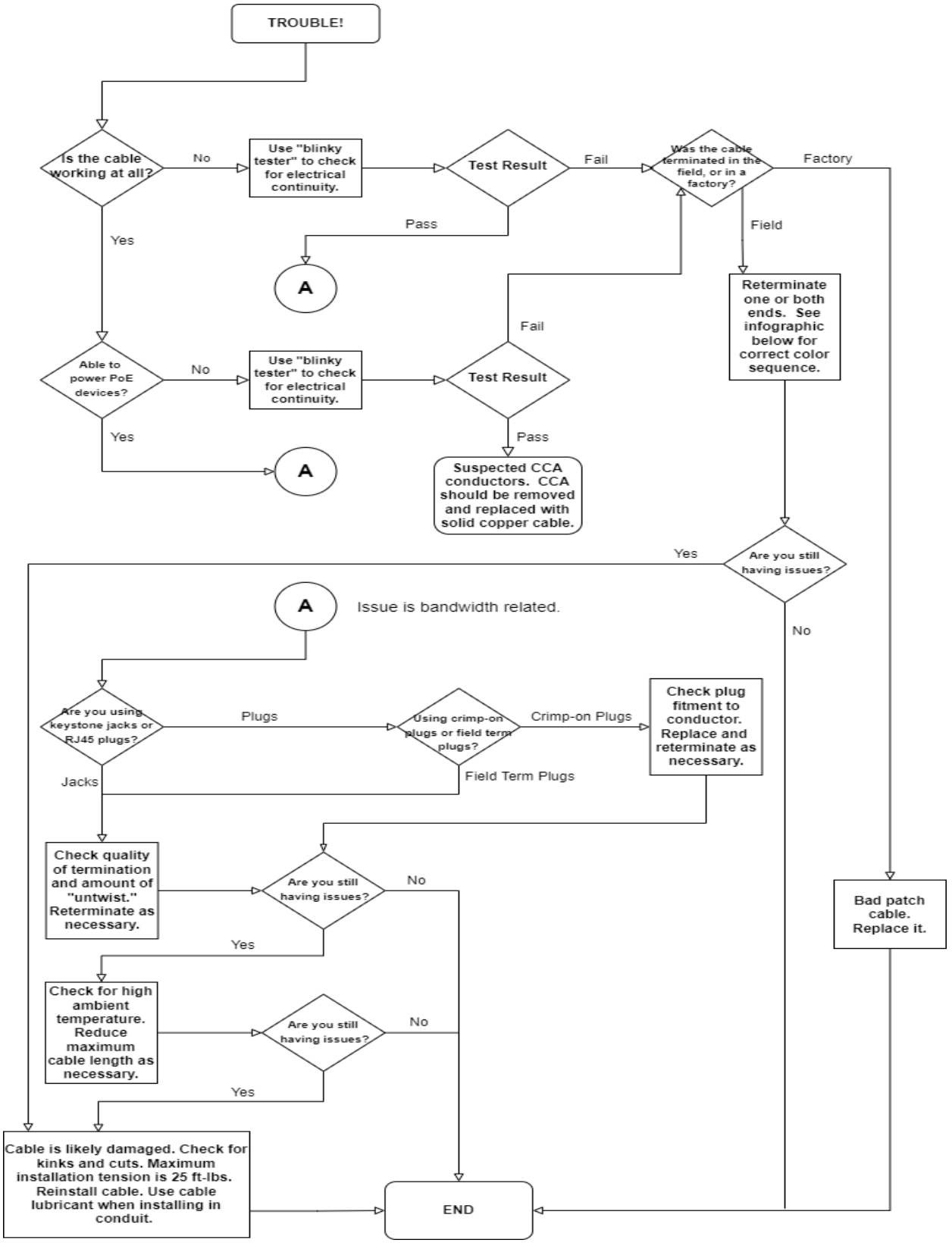
Fault	Cause	Equipment	Remedy
Bad connector	Dirt or damage	Microscope	Cleaning/ polishing/ retermination
Bad pigtail	Pigtail kinked	Visual fault locator	Straighten kink
Localized cable attenuation	Kinked cable	OTDR	Straighten kink
Distributed increase in cable attenuation	Defective cable or installation specifications exceeded	OTDR	Reduce stress/ replace
Lossy splice	Increase in splice	OTDR	Open and redress
	Loss due to fiber stress in closure	Visual fault locator	
Fiber break	Cable damage	OTDR Visual fault locator	Repair/replace

4.2.2: Cable system faults

Notes

4.2.3 Problem Identification Flowchart

Following is the problem identification flowchart:



4.2.3 : Problem identification flow chart

4.2.4 Preparing for fault Rectification

Understanding and adherence to the following is mandatory for fault rectification:

1 Following are important questions to be asked before embarking on fault rectification:
- Fault could be one of the breaks interrupting service. It could be considered as loss point that could check/verifies and solved?
- How long is the route- 100 m or 100 Km? Cabling type?
- What sort of fault locator is readily available?
- Who is available with which skills?

2 Following challenges are encountered during fault rectification:
- Without link disruption, Transmission signal is difficult to measure and sometime it is impossible.
- In case of locating, it's difficult to locate Non-metallic cables.
- specific device/ instruments are brought in practice for localization/identification of optical fiber fault.
- Route lengths can be very long e.g., 100 Km.
- Unavailability of skilled staff.

3 Instruments used for locating faults:
Specific device/ instruments are brought in practice for localization/identification of optical fiber fault-
- Optical time-domain reflectometer (OTDR).
- Optical power meter (OPM).
- Pen-type visual fault locator (VFL).
- Optical microscope.

OTDR

OPM

VFL

Optical Microscope

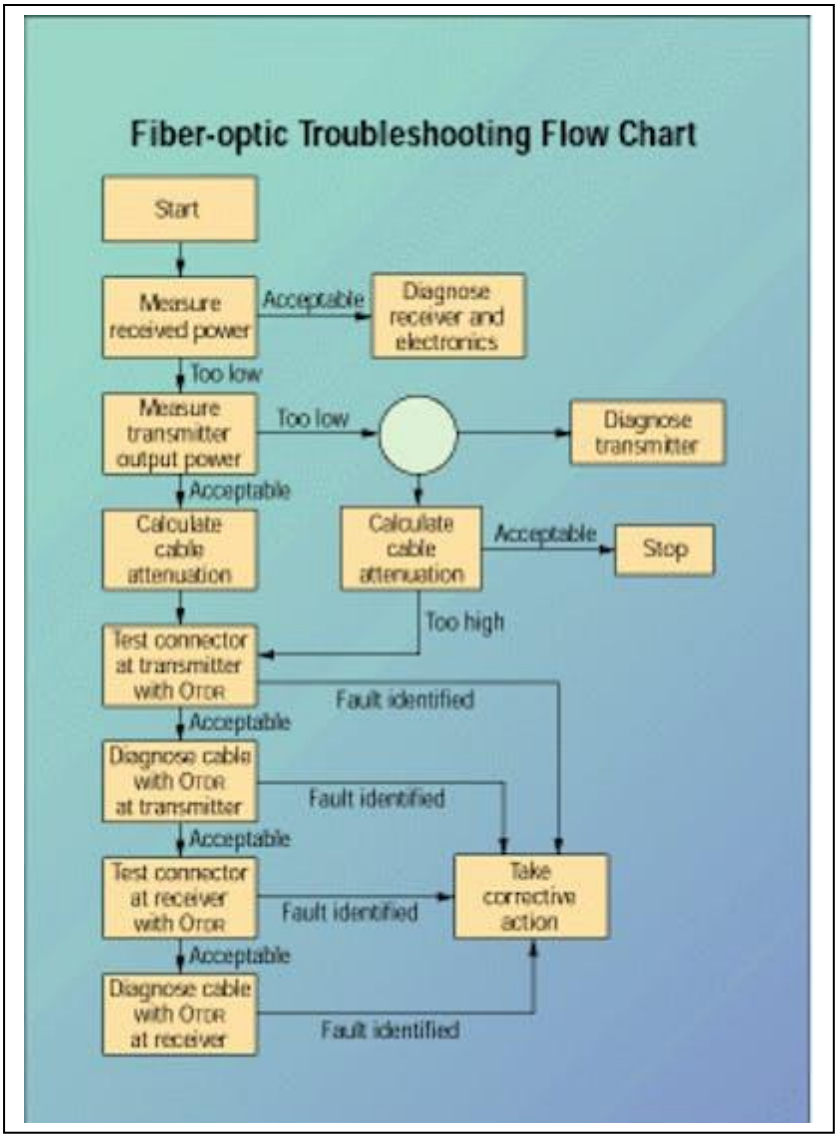
Fusion Splicing Equipment

4.2.4 : Instruments used for locating faults

4.2.5 Steps - OFC Restoration Process

Process depends on the following for efficient fiber optic communication:

- Continuously facing the problem?
- Having information of fixing it?
- Having the correct spares and brings out the work done quickly and efficiently?
- In case of emergency, having clear guidelines/planning could reduce the issues encountered.



4.2.5 : 'OFC' restoration process

4.2.6 Work Instructions

It is essential to follow the following work instructions for better quality and enhanced efficiency:

1 Following are the 'Work Instructions' for mobilization:

- Driver shall be available for 24 Hrs (mostly).
- Driver to move only on instructions of the designated SPOC.
- On receiving information of a cut in cable, technician will move to the site.
- Driver to prepare the van with all the technical tools/equipment and also should check breaks, fuel in the van.
- At the site if the cut is measured, technician to conduct OTDR measurement and a visual inspection.
- Labor from the nearest location is picked if the cut is near the site else arrange labor.
- Two spare fibers must be patched at each site for measuring cut location quickly and easily.

2 Following is the 'Work Instructions' for travelling:

- Team will either rush to the place of the cut or to the place nearest to the same.
- Before leaving - driver/technician to note kilometer reading.
- Ensure minimum travel time, by taking alternate routes.
- Avoid routes with chances of traffic jam, bad-road, etc.
- Reach quickly with or without following the OFC route.

3 Following is the 'Work Instructions' for localization:

- Teams to move along the OFC route while locating the cut. Teams to move the exact distance as measured by the OTDR from the initial reading of the kilometer before moving.
- Teams should carry 'as-built drawings' with them & should have proper knowledge of the OFC route. Teams to look for any digging activity going on near the cut location as measured by the OTDR; if digging activity is found they will search for the cut.
- If cut is not found they will move on feet for locating the cut carrying torches with them (during the night). If cut is not visible teams to locate the nearest manhole and take traces again.
- Once the team reaches the location they should start digging. Digging should expose at least 5 meters of OFC on either side.

4 Following are the 'Work Instructions' for OTDR trace measurement:

- During OTDR trace measurement check live fibers first.
- 5 spare fibers should be checked besides the live fibers.
- Care should be taken while handling OTDR. Connector should not be loosened without any reason. Teams to carry a spare connector & patch chords with them.

UNIT 4.3: Preventive and Corrective Maintenance

Unit Objectives

At the end of this unit, you will be able to:

1. Describe maintenance
2. Perform corrective maintenance activities
3. Describe and demonstrate corrective maintenance process
4. Explain the outline and fill corrective action report (reporting & documentation)
5. Describe and demonstrate the preventive maintenance process
6. Explain the outline and fill the preventive maintenance sheet (reporting & documentation)
7. Describe and demonstrate planned outage sub-process
8. Describe and demonstrate spare management process

4.3.1 Maintenance

1 OFC Maintenance is keeping close watch on the cable routes to prevent OFC damage & disruptions. It means a periodic check on:

- The cables.
- Microscopic verification of spare parts/connectors and connecting adapters.
- Insertion loss checking or obtaining OTDR traces.

2 Corrective Maintenance:

- Corrective maintenance is executed on continuation of fault or issue upcoming, with the aim of bringing back operations of the links/cable.
- In certain cases, it might be equal to expect or avoid a failure, making this type of maintenance is the only option.
  E.g. damage occurring due to natural calamities like flood or earthquake.

3 Preventive Maintenance

The Service & care by qualified staff for the idea of maintaining devices and provisions in satisfactory operating situation by giving for systematic verification, finding out, and correction of early failures either before they happen or before

Duct integrity tests, like air tightness and kink free tests:
The DIT-Duct Integrity Test is a comprehensive set of tests carried out on the duct that will be buried beneath optical cable. It is the phase that comes after cable jetting within the duct but before duct laying.

In addition to being useful for cleaning before installing O F C in Plb/silicore ducts of different diameters 32mm, 40mm, and 50mm in a safe environment, duct integrity test apparatus can be easily used for testing of various parameters like duct alignment, air tightness test, shuttle test, and more.

The basic goal of a duct integrity test is to determine and confirm whether a duct is suitable for installing optical fiber cables using jetting, blowing, or cable pulling.

What is done in DIT?

- Verify that the duct is continuous.
- Remove any mud, stones, or water from the duct.
- Look for kinks, obstructions, and sharp turns.
- Inspect the duct for any leaks of any kind and fix the problems.

4.3.3 The 4 Duct Integrity

Test	Description	Purpose
Air Blowing	Complete Discharge from Compressor	Verify for duct continuity
Shuttle Blowing	Dia. 80% of duct I.D. and length 150mm for 40/33mm duct	Verify for kinks, dents and sharp bends
Sponge Blowing	Dia. Twice the duct I.D,4 inch in length then min. density 28gms/cft	Clean the duct of mud, stones, water, etc.
Air Pressure	Permit 5 bar for 30 minutes. Permissible drop consider 0.5 bar	Verify for leakage and punctures

4.3.4 Duct Integrity

Following is some of the faults which can occur while performing duct integrity test

- Improper duct laying
  - Bending radius not maintained while trenching
  - Uneven trench bottom/ faulty trenching
  - Decoiler not used while uncoiling.
- Duct not continuous
  - Missing section of the duct
  - Coupler not installed.
- Kink in the duct
  - Spiraling due to non-use of decoiler
  - Boulder used in back-filling the trench
  - Sharp bend could be occurred in duct at 900 crossings/ culvert, etc.
- Mud & Water in duct
  - End plug not used while duct laying
  - Ends not coupled/ not sealed before back-filling
  - Duct laid in water-filled trench or laid on a rainy day.
- Leakage in the duct
  - Duct damaged while handling/ laying
  - Duct not checked before laying
  - Leakage at Couplers:
    - Improper duct cut
    - Improper sequencing of the coupler parts
    - Coupler not sufficiently tightened.

Safety measures to be adopted

- When DIT is being done, avoid entering the pit.
- When DIT is being done, avoid standing in front of the ducts when:
- Air/ Shuttle/ Sponge/ Transmitter is blown.
- Suddenly, do not open couplers or PTE before pressure is completely released.
- Use caution tape and cones whenever pits are opened to ensure safety.
- Use the proper warning cone and tape around the compressor for proper identification for moving traffic

Concept and various elements of an as-build drawing for optic fiber cable

Since the AS-Built document for the fiber optic project is one of the most important ones that must be given to the fiber maintenance team, it is required to be more accurate than the suggested route drawing.

This diagram displays the fiber route and other important details. The text is split into two halves.

THE LEFT PORTION: The project area is in THE LEFT PORTION. The drawing area on the left is where the line and point features are displayed.

THE RIGHT PORTION: The section including project details. Information about the drawing is contained in the right portion.

THE LOWER PORTION : The legend area is in the lower portion.

4.3.5 Standard Operating Procedure

As one of the key documents to be sent to the maintenance crew, the As-Built document is extremely important to the project. This document serves as the maintenance team's initial point of contact, helping them become familiar with the route; as a result, more accuracy is anticipated than in the proposed route drawing.

SOP Manual for Fiber Optic Cable
Standard Operating Procedures (SOPs) are written instructions with predetermined details designed for repeated use as a best practise.

The employee can find all the details they require in the manual to carry out a work accurately and consistently. After the initial investment is made to design the manual, a strategy for managing an update process for it and keeping it readily available to employees should be included. They work best when combined with staff training and performance reviews. Clarity, direction, effective communication, and work consistency are all provided by well- written SOPs.

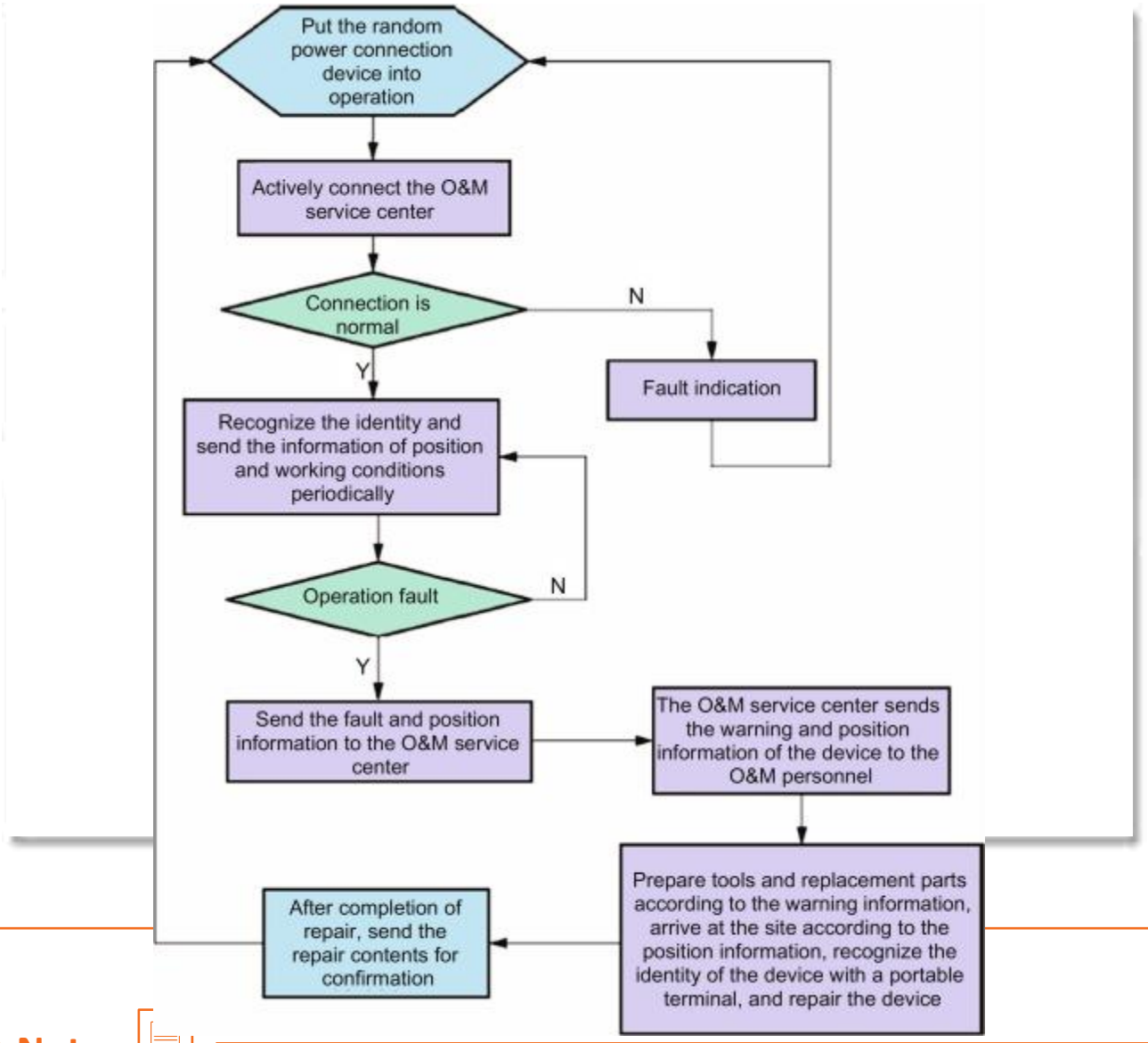
The creation of SOPs must be collaborative. The participation of management and all staff levels ensures the most successful compilation while fostering a great teamwork environment. Success for the business becomes a definite shared objective at every level.

A crucial stage is assigning the right people the right tasks.

SOPs are effective instruments that establish control over work processes. It finally creates a roadmap on the difference between success and failure by detailing every last element. Additionally, the SOP's successful communication increases staff engagement, motivation, and general satisfaction.

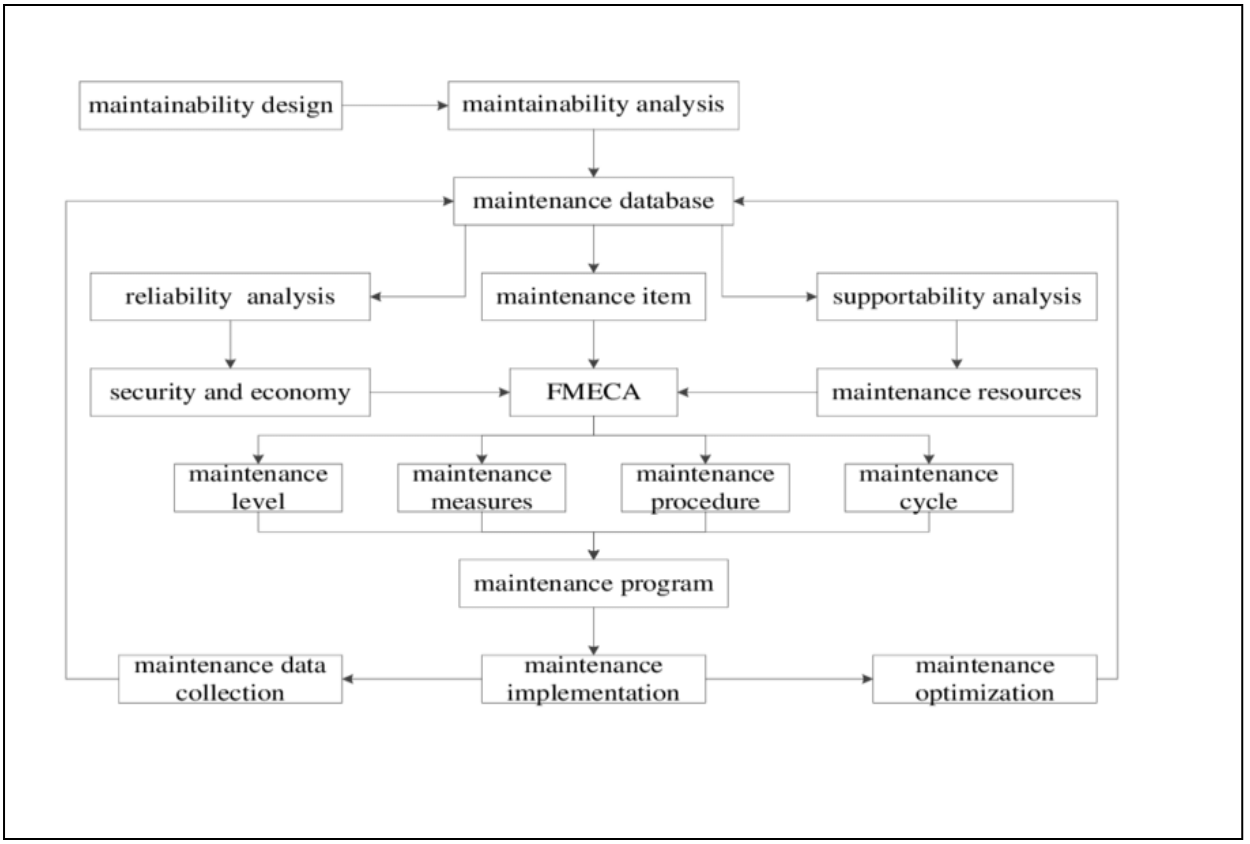
When done properly, the process requires a significant time commitment, but once a SOP is developed, the stages are logical and the time investment pays off.

4.3.3 Corrective Maintenance Process



Notes

4.3.5 Preventive Maintenance Process



4.3.4: Preventive maintenance process

Notes

4.3.6 Reporting - Preventive Maintenance Checklist

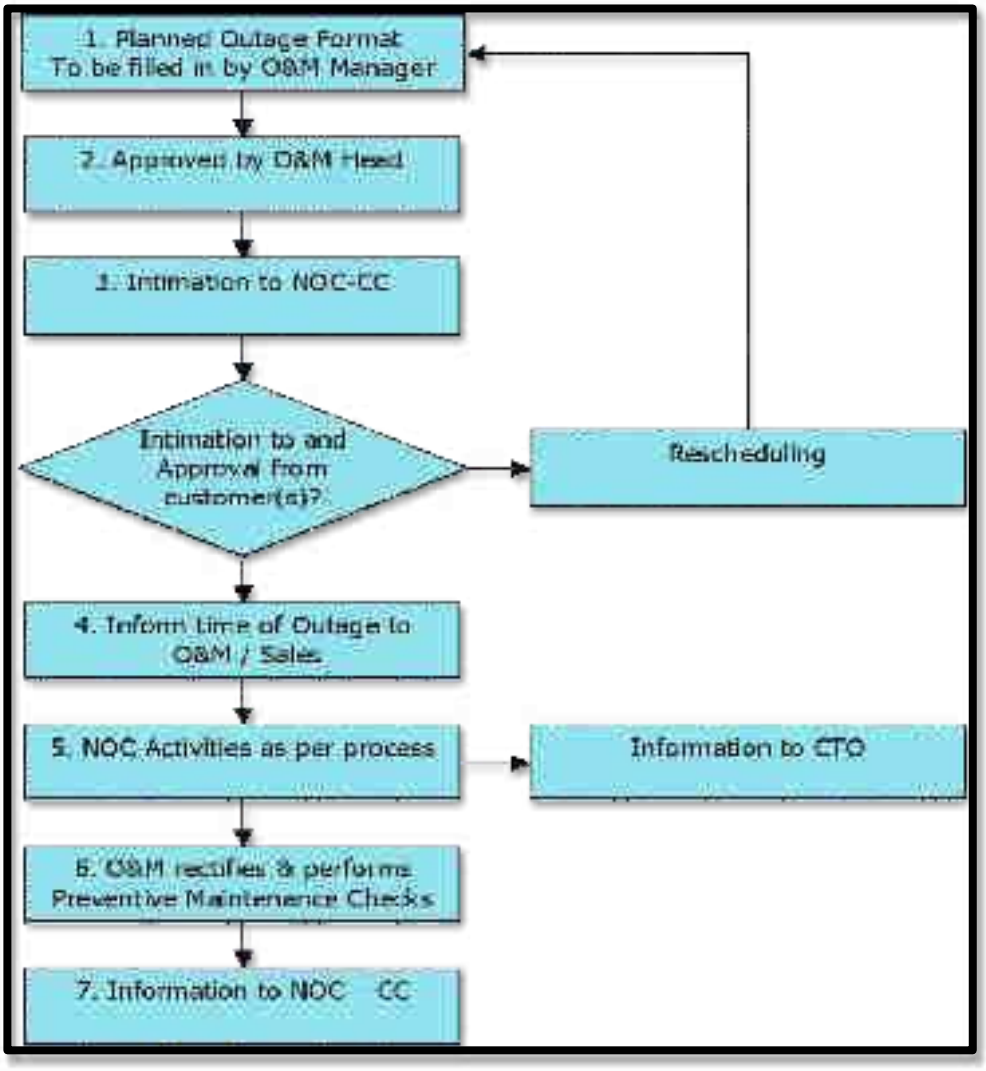
Environmental Tests	Optical Parameters	Optical Parameters (continued)	Mechanical Tests	Geometrical/Dimensional
Post life aging	Attenuation rate	Numerical aperture	Dynamic tensile strength	Core diameter
mechanical strippability	Attenuation uniformity	Polarization mode dispersion (lumped)	Mechanical strippability	Core ovality
Storage temperature	Bandwidth	Transient attenuation	Fiber curl	Cladding diameter
Temperature cycling	Chromatic dispersion		Tensile proof	Cladding ovality
Temperature life	Cut-off wavelength	Material Tests	Macrobending loss	Core-to-cladding eccentricity
Temperature/Humidity	Macrobend attenuation	Fluid immersion aging	Microbending loss	Coating diameter
cycling	Mode field diameter	Fungus resistance	Fatigue	Coating-to-cladding eccentricity
Thermal shock	Modal dispersion	Radiation resistance		Coating concentricity
		Salt spray	Visual Inspection	Coating uniformity
		Stress cracking factor	Fiber length	
			Fiber mass/unit length	

Table 2: Fiber Optic Cable Characteristics Checklist

Abrasion/scraping resistance	Corner bend	Flammability	Pressure withstand
Acid gas generation	Crosslink verification	Fluid immersion	Radial compression
Altitude cycling	Crosstalk	Freezing water immersion	Ribbon delamination
Attenuation rate	Crush	Fungus resistance	Shock
Bandwidth	Cyclic flexing	Halogen/toxicity content	Storage temperature
Cable-to-cable abrasion	Change in optical transmittance	Hosing	Temperature cycling
Cable jacket tear strength	Cold bend	Impact	Tensile loading and elongation
Cable element removability	Dripping	Jacket self adhesion/blocking	Thermal shock
Cable jacket material tensile strength & elongation	Dynamic bend	Knot	Toxicity index
Cable kinking	Electromagnetic effects	Life aging	Water absorption & Humidity
Cable shrinkage	Flame extinguishing	Marking Permanency	Weathering
Cable twist bending	Flame propagation	Operating tensile load	Weight
Color	Flaming smoke generation	Pressure (barometric)	Wicking

4.3.5: Monthly preventive checklist

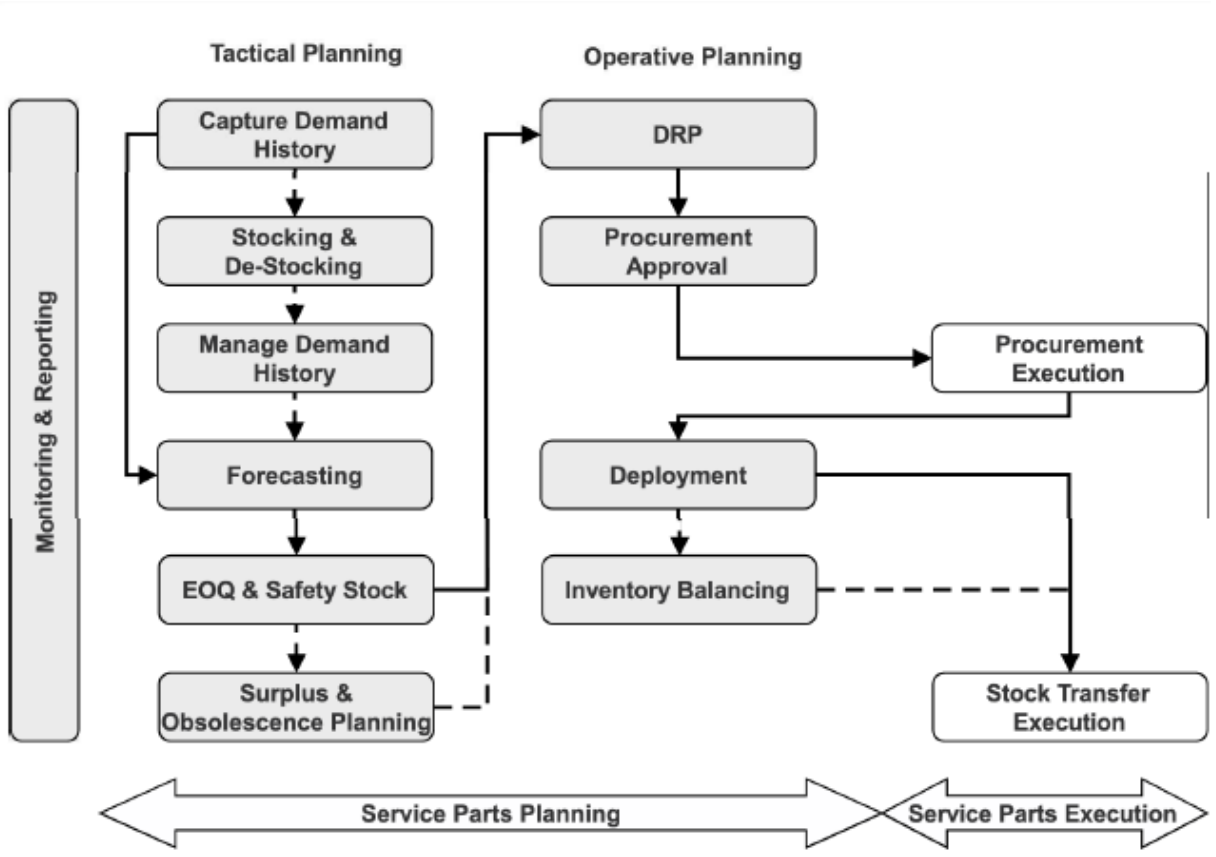
4.3.7 Planned Outage Sub-Process



4.3.6: Planned outage sub process

Notes

4.3.8 Spare Management Process



4.3.7: Spare management process

4.3.9 Work Instruction - Maintenance

1 Following is the 'Work Instructions' for maintenance:

- Obtain a site layout /design from NOC for patrolling purposes.
- Ensure permits and sign offs for conducting maintenance activities.
- Conduct periodic patrolling as per maintenance plan so as to prevent cable disruptions along the OFC routes.
- Conduct corrective maintenance as per SLA.
- Ensure availability of equipment & skilled staff for the purpose.
- Tested report of fiber sections is updated to respective as per the timelines.

2 Following is the 'Work Instructions' for maintaining equipment of POP:

- Obtain the maintenance schedule from NOC.
- Executing seasons/timings (monthly, quarterly, half yearly) maintenance activities as per plan.
- Make sure completion of physical maintenance operations like verifying battery voltage levels, electrolyte levels; DG set auto-start, oil levels; Air conditioner gas level.
- Filter condition; earthing, fire alarm system and another owner equipment (including MCBs).
- Ensure general upkeep of co-located electronic equipment and to make sure checking of alarms in line with NOC.

Exercise

1. On receiving information for 'OFC' cut technician should:

a. Immediately proceed to the site
b. Carry all the relevant tools and spares
c. Move in a van after checking it thoroughly for – brakes, tyres, engine oil, etc.
d. All of the above

2. Which is the correct sequence for dealing with fault notification:

a. Fault acknowledge, receive and clear
b. Fault receive, acknowledge and clear
c. Fault acknowledge, clear and receive
d. None of the above

3. Most appropriate cause of a bad connector fault is:

a. Kinked cable
b. Splice loss
c. Cable damage
d. Dirt or damage

4. If a fiber breaks the most suitable remedy is:

a. Reduce stress on cable
b. Repair and replace
c. Cleaning and polishing
d. All of the above

5. Cleaning and polishing is an ideal remedy for:

a. Bad pig-tail
b. Damaged fiber
c. Bad connector
d. All of the above

Exercise Cont.

6. Bad connector fault can be identified with the help of which equipment:

a. OTDR
b. Microscope
c. Visual fault locator
d. None of the above

7. Fiber break can be identified with the help of which equipment:

a. OTDR
b. Microscope
c. Visual fault locator
d. Both a and c

8. Bad pig-tail fault can be identified with the help of which equipment:

a. OTDR
b. Microscope
c. Visual fault locator
d. None of the above

9. Remedy for localized cable attenuation:

a. Polishing / cleaning
b. Reduce stress / replace
c. Straighten kink
d. None of the above

10. For quick and efficient fault restoration we should:

a. Rapidly find the problem
b. Knowing how to fix it
c. Have the right parts
d. All of the above

Exercise Cont.

11. What is a Fault?

12. List the fault notification process.

13. What are the workmanship guidelines to be followed?

Exercise Cont.

14. What is a fault localization?

15. What is a fault rectification?

16. List the type of cable system faults and causes for failure.

17. List the problem identification steps.

18. What kind of challenges you might face while locating faults?

19. Name the tools you would use for fault localization.

Exercise Cont.

20. What is an OFC restoration?

21. List the work instructions to be followed while mobilization, travelling, OTDR trace measurement & localization.

Exercise Cont.

22. What is a difference between corrective & preventive OFC maintenance?

23. List the preventive maintenance process.

24. List the corrective maintenance process.

25. List the planned outage sub-process.

26. List the spare management process.

Exercise Cont.

27. What is the purpose of maintenance checklist & what all it contains?

28. What is the purpose of CAR?

29. List the work instructions for maintenance & POP.

Exercise Cont.

30. List the importance of documentation.

31. 'Documentation is of great help in finding faults'. Explain the statement.

32. List the importance of reporting status.

Tips

Following are recommended tips:

- Visit an OFC site and have a detailed look at the entire process of maintenance under the supervision of your instructor
- Ensure you check out the processes with field reality
- Make sure that you talk to the existing OFC technician to understand the entire corrective and preventive maintenance process in a proper manner

Notes

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GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
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N·S·D·C
National
Skill Development
Corporation
Transforming the skill landscape

5. Organize Resources and work effectively and safely

Telecom Sector Skill Council

Unit 5.1 – Workplace Health and Safety

Unit 5.2 – Different Types of Health Hazards

Unit 5.3 – Importance of Safe working Practices

Unit 5.4 – Reporting Safety Hazards

Unit 5.5 – Waste Management

Unit 5.6 – Organizations' Focus on Greening of Jobs

TEL/N9101

Key Learning Outcomes

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

1. Explain about the work place health and safety
2. Differentiate various health hazards
3. Demonstrate various first aid techniques
4. Importance of safety at workplace
5. Understand Basic hygiene Practices and hand washing techniques
6. Explain the need for social distancing
7. Understand the reporting of hazards at workplace
8. Explain e-waste and process of disposing them
9. Explain Greening of jobs

UNIT 5.1: Workplace Health & Safety

Unit Objectives

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

1 Understand about workplace health and safety
2 Explain tips to design a safe workplace
3 Explain precautions to be taken at a workplace

5.1.1 Safety: Tips to Design a Safe Workplace

Every organization is obligated to ensure that the workplace follows the highest possible safety protocol. When setting up a business some tips to remember:

- Use ergonomically designed furniture and equipment to avoid stooping and twisting
- Provide mechanical aids to avoid lifting or carrying heavy objects
- Have protective equipment on hand for hazardous jobs
- Ensure presence of emergency exits and they are easily accessible
- Set down health codes and ensure they are implemented
- Follow the practice of regular safety inspections in and around the workplace
- Get expert advice on workplace safety and follow it
- Get regular inspection of electrical wiring and also the electrical switches and gadgets
- Install fire extinguishers and fire alarms.

5.1.2 Non-Negotiable Employee Safety Habits

Every employee is obligated to follow all safety protocols put in place by the organization.

All employees must make it a habit to:

- Immediately report unsafe conditions to the supervisor
- Recognize and report safety hazards that could lead to slips, trips and falls
- Report all injuries and accidents to the supervisor
- Wear the correct protective equipment when required
- Learn how to correctly use equipment provided for safety purposes
- Be aware of and avoid actions that could endanger other people
- Always be alert
- Educate the employees about the first/emergency exits on the floor, and also where the fire extinguishers are kept.

Tips

1. Be aware of what emergency number to call at the time of a workplace emergency
2. Practice evacuation drills regularly to avoid chaotic evacuations

UNIT 5.2: Different types of Health Hazards

Unit Objectives

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

4 Understand the health hazards

5 Demonstrate First Aid Techniques

5.2.1 First Aid

Illness, injuries, and pain are part of human life. This can happen anyway. Every individual is prone to illness and injuries at any time and anywhere.

In case of any of these, some kind of immediate medical attention or treatment is needed to reduce the discomfort, pain, and deterioration of the condition. The medical attention that is given at the first instance before seeking professional medical help is called “First Aid”. First aid is the immediate and temporary treatment given to the victim of an accident or sudden illness while awaiting the arrival of “Medical Aid”. First Aid means providing the initial treatment and life support for people with an injury or illness. However, First Aid has its limitations and does not take the place of professional medical treatment. Proper early assistance given by First Aider helps in saving the life of a patient.

Illness and injuries can happen anywhere, be at home, the workplace, or in the market place. Whatever safety measures we adopt, we are all prone to illness sometime or the other.

Some common injuries and their rescue techniques:

5.2.2 First Aid Techniques

- Direct pressure must be applied to the cut or wound with a clean cloth, tissue, or piece of gauze, until bleeding stops.
- If blood soaks through the material, it is highly recommended not to remove it.
- More cloth or gauze must be put on top of it, and pressure must be continued.
- If the wound is on the arm or leg, the limb must be raised above the heart to help slow the bleeding.
- Hands must be washed again after giving first aid and before cleaning and dressing the wound.
    - A tourniquet must not be applied unless the bleeding is severe and not stopped with direct pressure.

Click / Scan the QR code for First Aid Techniques

Fig. 5.2.1: clean cut or wound

Clean cut or wound

- The wound must be cleaned with soap and lukewarm water.
- To prevent irritation and burning sensation, the soap solution must be rinsed out of the wound.
- Hydrogen peroxide or iodine must not be used to clean or treat the wound since they are corrosive and can damage live tissues.

Fig. 5.2.2: Apply hydrogen peroxide or iodine

Protect the wound

- Antiseptic cream or solution must be applied to the wound to reduce the risk of infection.
- Then the wound must be gently covered with a sterile bandage.
- Till the wound heals, the bandage must be changed (dressed) daily to keep the wound clean and dry.

Fig. 5.2.3: Protect the wound

Call the Emergency Helpline if:

- The bleeding is severe and deep
- You suspect Internal Bleeding
- Abdominal or Chest wound exists
- Bleeding continues even after 10 minutes of firm and steady pressure

For Burns:

- Immediately put the burnt area under cold water for a minimum of 10 minutes
- If the burned area is covered, take clean scissors, cut and remove the fabric covering the area
- In case clothing is stuck to the burned area, leave it as it is
- Before sterile dressing application, remove jewellery (if any)
- It is better to leave the burned area open
- Do not apply any medication or ointment
- Breaking a blister – it is an absolute no-no!

Fig. 5.2.4: Put Burnt Area under Water

For Broken Bones and Fractures

- Protruding bone must be left alone
  - If a bone has broken through the skin, it must not be pushed back into place.
  - The area must be covered with a clean bandage and immediate medical attention must be sought.
- Bleeding must be stopped
  - Steady and direct pressure must be applied with a clean piece of cloth for 15 minutes and the wound must be elevated.
  - If a blood soaks through, one must apply another cloth over the first and seek immediate medical attention.
- Swelling must be controlled
  - The RICE (Rest, Ice, Compression and Elevation) therapy must be applied to control and reduce swelling.
  - Rest the injured part by having the person stay off of it.
  - Ice must be applied on the area with the help of an ice pack or by wrapping the ice in a clean cloth. Ice must not be directly placed against the skin.

For Heart Attack/Stroke

- Think FAST. Face: is there weakness on one side of the face? Arms: can they raise both arms? Speech: is their speech easily understood? Time: to call Emergency helpline
- Immediately call medical/ambulance helpline or get someone else to do it

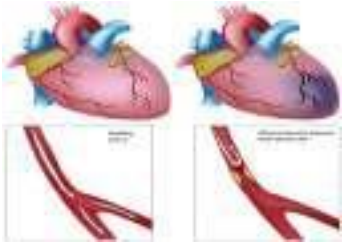

Fig 5.2.5: Anatomy of Heart Attack

For Head Injury

- Ask the victim to rest and apply a cold compress to the injury (e.g. ice bag)
- If the victim becomes drowsy or vomits, call Medical helpline or get someone else to do it Steps of using breathing apparatus:

Check the parts of the breathing apparatus thoroughly.

Check the bypass knob (red). Close it if you see it open. After this, press the reset button (area above bypass nob – black)

Inspect the facemask to see that it is undamaged.

Lift the cylinder ensuring that on the top the cylinder valve should be present.

The back plate of the cylinder should face the wearer.

Wear the breathing apparatus on the shoulder like a bag pack and by the neck strap, hang the facemask.

After wearing the breathing apparatus tighten shoulder straps and fasten the waist belt

The cylinder valve should be opened slowly to inspect the pressure gauge.

Make sure that 80% of the cylinder is full.

Wear the mask slowly by resting your chin in the resting cusp and pull the head strap slowly over your head.

Pull the head straps for a snug but comfortable fit.

Breath in and normally to see if you can breathe normally or not.

Now insert a finger sidewise of the facemask for easy outward airflow.

Slowly close the cylinder valve without leaving the knob.

Be steady for 10 minutes and hold your breath or extremely slow to listen to any wheezing sound.

Also, check the pressure gauge for any dip in the pressure.

Normally Breathe to vent system

Listen for a whistle alarm while observing the pressure gauge at 55 bar (+/-5 bar)

Table: 4.2.1: Steps of using breathing apparatus

Briefing and Guidance for Fire Fighters

There are basically three methods with the help of which people can be rescued from a building engulfed in a blazing fire. To ensure on-site reception, here are two of the important steps that we will discuss now. These come under the best safe lifting and carrying practices.

Conventional Technique: This is a good method if there is an open area close by. The first rescuers will make the victim sit reach under their armpits and finally, grab their wrist. The other rescuer will cross the ankle (victim), pull up that person's legs on his shoulder. Finally, on the count of 3, both will lift the person up and move out.

Fast Strap: In case the victim is completely incapable of moving out of the fire zone. The rescuers should follow this method. One of the rescuers will place their knee between victim's shoulder and head. Pin the loop of webbing to the ground with the help of the knee. This acts as an anchor. With the non- dominant hand hold the other end of the webbing and make a loop. With steady hands, pull the victim's hand in from the loop, tie it securely and finally clip the webbing loops.

Fig. 5.2.7: Fast Strap

Essentials for Smooth Evacuation: The following are essential to have a smooth evacuation during an outbreak:

- Clear passageways to all escape routes
- Signage indicating escape routes should be clearly marked
- Enough exits and routes should be present to allow a large number of people to be evacuated quickly
- Emergency doors that open easily
- Emergency lighting where needed
- Training for all employees to know and use the escape routes
- A safe meeting point or assembly area for staff
- Instructions on not using the Elevator during a fire

Special Evacuation Requirements for Specially Abled Persons

- The Visually Impaired
  - Announce the type of emergency
  - Offer your arm for help
- With Impaired Hearing
  - Turn lights on/off to gain the person's attention, or indicate directions with gestures, or write a note with evacuation directions
- People with Prosthetic Limbs, Crutches, Canes, Walkers
  - Evacuate these individuals as injured persons.
  - Assist and accompany to evacuation site if possible.
  - Use a sturdy chair, or a wheeled one, to move the person to an enclosed stairwell
  - Notify emergency crew of their location

5.2.3 Importance of Fire Safety Drills

Fire drills are indispensable in any workplace or public building for rehearsing what to do in the event of a fire. They are also a lawful obligation under the Fire Safety Order of 2005 and all workers in a company must partake. Here's how to get the most out of your fire practice.

Why have fire drills?

There are numerous reasons why fire drills are vital; first of all, fire drills are a chance to practice evacuation techniques to make sure all staff are acquainted with them. The staff will vacate the building quickly and therefore in a real life situation panic will be decreased, as everyone will know what they need to do. Fire drills are also beneficial for testing escape methods to assess their efficiency.

During fire drills, checks can also be carried out on alarm systems to make certain they are working properly and that emergency exits are passable. Overall fire drills help increase safety, so that you will be best equipped if a real fire does happen.

How often?

Ideally there should be two fire drills a year, although this may vary according to the workplace and after checking the firm's risk assessment. If there are people who work in shifts, suitable preparations should be made to ensure all staff partake in at least one fire drill per year and to educate them as to how to handle the situation.

Should you inform staff beforehand?

There are arguments for and against making people conscious of fire drills before they take place. Some people contend that not notifying staff gives an element of surprise, so that people take drills more sincerely. However, this can also have the reverse effect in a real fire, as on overhearing the alarm people may reason that it's only a drill.

The benefit of notifying all staff of fire drills in advance is that initially, they will not panic, which circumvents potential injuries that could be instigated in a rush to exit a building. Furthermore, if the alarm sounds, lacking a prior warning, there will be no uncertainty as to if it is a drill or not and people will act correctly. In public places such as shopping centres, it is prudent to make members of the public alert when a drill is about to happen.

Fig. 5.2.3: Fire exit signage

UNIT 5.3: Importance of Safe Working Practices

Unit Objectives

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

1. Explain Basic Hygiene Practices
2. Understand the importance of Social Distancing
3. Demonstrate the safe working practices

5.3.1 Basic Hygiene Practices

We are living in an environment with millions of germs and viruses. And our body can be a breeding space for these microbial organisms. They grow and multiply and cause many diseases which sometimes can prove to be fatal for the human beings. These disease-causing microbial organisms kill over 17 million people every year. Some simple hacks and little changes of basic personal hygiene habits can bring amazing changes to all of us. We can prevent contracting these diseases if we follow these hygiene practices every day.

Personal Hygiene

Personal hygiene is all about managing your body hygiene, essentially caring for your well-being incorporating some physical hygiene habits. Also, there are mental health benefits as well, as they affect each other immensely.

What are good personal hygiene habits?

Good personal hygiene includes but not limited to-

- Take regular shower
- Maintain oral hygiene
- Wash your hands frequently
- Wash your genitals
- Keep your clothes and surrounding dry and clean

These habits should be practiced on a regular basis, at home, at work, basically where you are!

That's the whole idea of preventing your body system collapse over a tiny microbe!

Personal Hygiene Practices at Home

Your home should be the most comfortable and convenient for you to keep up your personal hygiene level to a standard, yet, we find ourselves procrastinating over hygiene issues when we are at home. Even though some of these tasks barely take a minute.

1. **Take Regular shower**

   Do not wait up to feel the dried sweat in your body to feel the urge to take shower, make it a routine, you have the choice to either take them before you head to work or after the long day or even before you head to sleep, whichever one suits your routine. Make sure to rinse your body thoroughly, especially the genitals and underarms as they produce more sweat and are more prone to fungal activities.

2. Wash your hands frequently

We use our hands to do our most physical acts, from picking up the keys, browsing through our phones, cooking or eating to attending our pets. While we agree and accept the importance of washing hands before eating and after visiting the toilet, it is also important to wash our hands with soap or sanitizer every now and then. The pandemic covid-19 which crippled the life all over the world has taught us an important lesson that sanitizing our hands regularly is the only way we can avoid transmission of the disease. Use alcohol-based sanitizer to wash hands well to prevent the spread of communicable diseases.

Fig. 5.3.1: 7 steps for Handwashing

3. Maintain oral hygiene practices

It is very important to take care of the teeth and gum, to prevent tooth decay and bad odour. Just brushing them twice a day is not enough, but using fluoride toothpaste and brushing properly is very essential. And wash it well with water to remove any food particles that is stuck in the gap in between the teeth. It is advised to wash the teeth everyday twice to maintain healthy teeth and gum.

4. Nails and hairs hygiene

The cleanliness of nails and hair is also very important. They store dirt and grease. And even the microbes could be in there stuck and spreading. If the nail is not clean they can cause severe food poisoning, as we use our hands to eat food. Trim the nails once in a fortnight and wash hair at least twice a week with a shampoo to keep them healthy

5. Nose and ears hygiene

Wherever we are most likely to breathe in some pollutants, and most of the particles are bound to be stuck in the nasal hair. So, rinse the nose and ear with warm water once you return from outside.

6. Wear fresh and clean clothes

Changing into neat and clean clothes will prevent many infectious diseases. It will also give the mental effect immediately and it will boost the mind. Wash clothes with a good detergent every day and dry it in the sun. This will ward off any microbes attached to the clothes. If possible, Dettol can be used while rinsing which is an anti-disinfectant.

7. **Food hygiene**

   You can get severely sick from food-borne diseases, as most of your foods are raw, purchased from outside, they risk being cross-contaminated with harmful microbes. Food hygiene is basically the idea of better storage, handling, and preparation of food to prevent contamination and to prevent food poisoning.

5.3.2 Importance of Social Distancing

Preventing communicable diseases:

All these above practices will help us to prevent communicable diseases. These diseases are highly infectious and contagious and spread through air, urine, faces, saliva, skin (through touch) and using same towels and utensils.

Social Distancing and isolation, Self-Quarantine:

Ever since the spread of the pandemic covid-19, several health organisations have been insisting on following social distancing and isolation. Communicable diseases mainly spread through coming close to the infected individual and through physical touch. If a person is infected with diseases like normal flu or cold and spread it to others, the symptoms and may remain with the infected person for a day or two. The virus may be destroyed by taking an antibiotic. But in severe cases like corona virus the infection is severe and can prove fatal to the affected people. To prevent the spread of the virus, the entire world adopted lockdown, social distancing and compulsory face mask. And the infected person has to be in self isolation and quarantine till the time the symptoms are over. This was the advisory from the World Health Organisation, and the entire world followed it to prevent the rapid spread of the virus. The same can be applicable to all types of communicable diseases that are spread mainly through air and touch.

As communities reopen and people are more often in public after the pandemic, the term “physical distancing” (instead of social distancing) is being used to rein-force the need to stay at least 6 feet from others, as well as wearing face masks. Historically, social distancing was also used interchangeably to indicate physical distancing which is defined below. However, social distancing is a strategy distinct from the physical distancing behavior.

What is self-quarantine?

Self quarantine was imposed on people who have been exposed to the new covid-19 and who are at risk for getting infected with the virus were recommended to practice self-quarantine. Health experts advised the self-quarantine for 14 days or two weeks. Two weeks provides enough time for them to know whether or not they will become ill and be contagious to other people.

Self-quarantine was also recommended for people who have recently returned from traveling to a part of the country or the world where COVID-19 was spreading rapidly, or if a person has knowingly been exposed to an infected person.

Self-quarantine involves:

- Using standard hygiene and washing hands frequently
- Not sharing things like towels and utensils
- Staying at home
- Not having visitors
- Staying at least 6 feet away from other people in your household

Click/Scan the QR Code to know more about handwash techniques

Once your quarantine period has ended, if the symptoms are not there, then the person may return to normal routine as per doctor's advice.

What is isolation?

Anybody who is infected with a contagious disease needs to practice isolation in order to prevent the spread of the germs to their near and dear ones. This became very popular and was strictly adhered to during the covid-19 pandemic. People who were confirmed to have COVID-19, isolation was mandatory. Isolation is a health care term that means keeping people who are in-fected with a contagious illness away from those who are not infected. Isolation can take place at home or at a hospital or care facility. Special personal protective equipment will be used to care for these patients in health care settings. They are attended by well trained nurses and specialised doctors. And these people have to be in the PPE kits all through their presence in the hospital.

Complete PPE Kit

Fig. 5.3.2: Complete PPE Kit

Disposing off the PPE Kits

The PPE kits are worn by health workers and doctors who are attending to patients with highly infectious diseases and who are kept is isolation in order to arrest the spread. They have to wear it every time they go near the patient and have to remove it once their duty is over. Most of the PPE components are used for single use, however the face mask and goggles can be reused provided they are sanitised properly. The PPE kits have to be disposed off safely as they might have contaminants stuck to them and they may infect the healthy person if they are not discarded properly. The health workers may be all the more vulnerable to contact the disease.

5.3.3 Safe Workplace Practices

Every company has the provision of first aid box. As you have already read about the types of injuries that technicians can receive in their field of work, it is imperative for the companies to have appropriate first aid accessories.

The basic first aid supplies and accessories that a first aid box should have are:

Supplies and Accessories in the First Aid Box

Splint

Elastic wraps

Latex gloves

Adhesive tape

Tweezers

Blanket

Scissors

Wound cleaning agent

Triangular bandages

Gauze roller bandage

Adhesive bandages

Gauze pads

Antiseptic cleansing wipes

Burn cream or gel

Eyewash liquid

CPR Kit

Chemical hazards are caused by toxic materials, which are poisonous. And being poisonous in nature, they can either be fatal or cause serious damages in case the preventive actions are not taken on time. Now, the exposure to chemicals can be in 3 forms.

They can be:

1. Inhaled (entering the body through nose)
2. Directly in contact with skin
3. Ingested (consumed)

The symptoms, in this case, will be:

4. Seizures
5. Partial or complete loss of responsiveness
6. Burning sensation
7. Stomach Cramping with bouts of excruciating pain
8. Nausea
9. Vomiting (and in times with blood-stains)

Now, where there are problem, their solutions come side by side. In such situations, the person giving first aid requires to be calm and take certain preventative actions.

Some of the essential actions are:

10. Using insulated equipment
11. Wearing protective clothing, goggles, masks, shoes and gloves
12. Ensuring the place has enough ample ventilation

Remedial action

13. The foremost thing that one should do is to provide immediate first aid. However, it is to be remembered that the victim should not be given any kind of fluid (water, milk) until doctors from Poison control unit gives a green signal.
14. Aside from this, there are a few things a person can perform to the victim of toxic material exposure.
15. Remove the victim from the toxic zone or vicinity
16. Call for an ambulance

1. Remove contaminated clothing
2. Splash water in the eyes
3. If ingested, do not try to make the victim puke (vomit)
4. Wash their mouth with water

Fig. 4.3.3: CPR

5. In case the victim's breathing has stopped, give CPR (Cardiopulmonary resuscitation)
6. In case of burning due to toxic material, apply burn gel or water gel on that area.
7. Avoid any cream based or oil based lotion or ointment
8. Even though giving first aid is the right thing to do in the first place, it is also important to report the incident to their supervisor.

Exercise

- Burnt area should be kept under _____ for a minimum of 10 minutes
- _____exits should be easily accessible in case of fire.
- _____or _____must be applied to the wound to reduce the risk of infection
- The RICE which is_____,_____,_____ and _____therapy must be applied to control and reduce swelling.
- CPR is _____.

Click/Scan the QR code to know CPR better

UNIT 5.4: Reporting Safety Hazards

Unit Objectives

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

- Discuss the process of reporting in case of emergency (safety hazards)
- Understand methods of reporting hazards

5.4.1 Methods of Reporting Safety Hazards

Every organization, from every industry, has a standard reporting protocol, comprising the details of people in the reporting hierarchy as well as the guidelines to be followed to report emergencies. However, the structure of this reporting hierarchy varies between organizations, but the basic purpose behind the reporting procedure remains same.

The general highlights of the Organizational Reporting Protocol, commonly known as the 6Cs, are:

- Communicate First
  - The first source of information during emergency is the preferred source.
  - Crises situations are time-bound and hence it is important to communicate promptly.
- Communicate Rightly
  - Distortion of information due to panic must be avoided.
  - Proper, accurate information must be provided to concerned authorities and this can save lives.
- Communicate Credibly
  - Integrity and truthfulness must never be forgotten during emergencies.
- Communicate empathetically
  - One must wear the shoes of the victims while communicating emergencies.
- Communicate to instigate appropriate action
  - Communicating to the right authorities help in taking the necessary action.
- Communicate to promote respect
  - Communicating with the victims with respect help in earning their trust and thus eases the disaster management process.

Hazards and potential risks / threats can be identified and then reported to supervisors or other authorized persons in the following ways:

While identifying and reporting a hazard / potential threat / potential risk, one must describe the following:

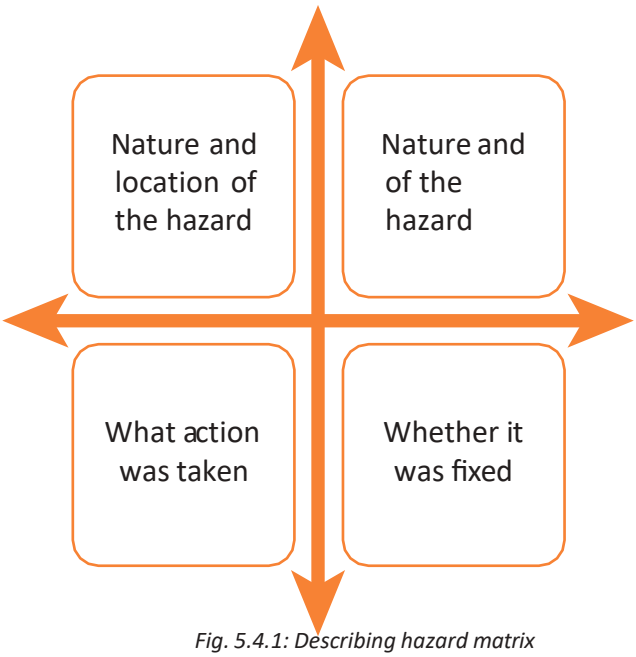

Fig. 5.4.1: Describing hazard matrix

Part A: To be completed by the Worker Details Required:

- Name of Worker
- Designation
- Date of filling up the form
- Time of incident / accident
- Supervisor / Manager Name
- Work Location / Address
- Description of the hazard / what happened (Includes area, task, equipment, tools and people involved)
- Possible solutions to prevent recurrence (Suggestions)

Part B: To be completed by the Supervisor / Manager Details Required:

- Results of Investigation (Comment on if the hazard is severe enough to cause an injury and mention the causes of the incident / accident)

Part C: To be completed by the Supervisor / Manager Details Required:

- Actions taken / Measures adopted (Identify and devise actions to prevent further injury, illness and casualty)

Action	Responsibility	Completion Date

Any job role and any occupation in this world have some hazards, in varying severity, associated with it. These are called Occupational Hazards. Occupational Hazard can be defined as "a risk accepted as a consequence of a particular occupation". According to the Collins English Dictionary, it is defined as "something unpleasant that one may suffer or experience as a result of doing his or her job". Occupational Hazards are caused by the following:

Hazard Report Form	
Name:	Date:
Location:	
Tool/Equipment:	
Description of the hazard:	
Suggested correction action:	
Signature:	
Supervisor's remarks:	
Corrective Action taken:	
Signature of Supervisor:	Date:

Fig 4.4.2: Sample form of reporting hazards

UNIT 5.5: Waste Management

Unit Objectives

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

1. Understand what is e-waste
2. Understand the concept of waste management
3. Explain the process of recycling of e-waste

5.5.1 Introduction to E-Waste

Electrical and electronic products are all around us. We can't imagine a world without these gadgets. Our life is indispensable without electricity and electronic devices. Growth in the IT and communication sectors has increased the usage of electronic equipment immensely. Frequent change on the technological features of electronic products is forcing consumers to discard their old electronic products very quickly, which, in turn, adds to e-waste to the solid waste pool. What this translates to is mountainous masses of electrical and electronic waste which has a high potential to pollute the environment. This growing menace of e-waste calls for a greater focus on recycling e-waste and better e-waste management.

E-waste means electrical and electronic equipment, whole or in part discarded as waste by the consumer or bulk consumer as well as rejects from manufacturing, refurbishment, and repair processes. E-waste usually is made up of usable and non-usable material. Some of the waste if left unattended will be destructive to the environment. E-waste is made up of hazardous substances like lead, mercury, toxic material, and gases.

There are many companies these days who are engaged in the collection, handling, and disposal of this e-waste in a safer and more secure place to protect the environment.

5.5.2 What is E-Waste?

The amount of e-wastes comprising computers and computer parts, electronic devices, mobile phones, entertainment electronics, refrigerators, microwaves, TV, fridges, and industrial electronics that are obsolete or that have become unserviceable is growing. All these electronic devices contain plastics, ceramics, glass, and metals such as copper, lead, beryllium, cadmium, and mercury and all these metals are harmful to humans, animals, and the earth. Improper disposal only leads to poisoning the Earth and water and therefore all life forms. Our effort is meant to preserve the environment and prevent pollution by proper handling of e-waste. While it will take a lot of effort to educate people to dispose of such wastes in the right way, we are doing our part by providing a channel to collect e-wastes and dispose off them in a sustainably safe manner. We convert waste to usable resources.

The electronic industry is not only the world's largest industry but also a fast-growing manufacturing industry. It has been instrumental in the socio-economic and technological growth of the developing society of India.

At the same time, it poses a major threat in the form of e-waste or electronics waste which is causing harmful effects on the whole nation. e-waste is creating a new challenge to the already suffering Solid waste management, which is already a critical task in India.

5.5.3 Electronic Goods/gadgets are Classified Under Three Major Heads

White goods: Household appliances,

Brown goods: TVs, camcorders, cameras etc.,

Grey goods: Computers, printers, fax machines, scanners etc.

The complete process is carried out as per the government guidelines.

5.5.4 E-waste Management Process

- Collection of e-waste from all the electronic stores, manufacturing companies, etc.
- Transport of e-waste to the disposal units
- Segregation of e-waste at the disposal unit
- Manual dismantling of e-waste to segregate components into various types such as metal, plastics and ceramics
- Convert into raw material (recycle and reuse)
- Supply recovered raw material to processors and electrical/electronic industries
- Dispatch hazardous e-waste for safe disposal

Waste management is carried out to ensure that all types of waste and garbage are collected, transported, and disposed of properly. It also includes recycling waste so that it can be used again.

Fig. 5.5.4: E-waste Management Process

Click/Scan the QR Code to know about eWaste Management

5.5.5 Recyclable and Non-Recyclable Waste

Recyclable waste is renewable or can be reused. This means that the waste product is converted into new products or raw material, like paper, corrugated cardboard (OCC), glass, plastics containers and bags, hard plastic, metal, wood products, e-waste, textile, etc

Recycling not only conserves important areas in our landfills but also assists decrease greenhouse gas emissions.

Contrary to this, Non-recyclable waste cannot be recycled and cause a major threat to the environment.

The following items cannot be recycled:

Shredded paper, aerosol cans, paper coffee cups, milk and juice cans, used baby diapers, and bottle caps.

Recycling is one of the best ways to have a favorable influence on the world where we live.

Recycling will greatly help us to save both the environment and us from pollution. If we take immediate action, we can control this, as the quantity of waste we are accumulating is increasing all the time.

5.5.6 Colour Codes of Waste Collecting Bins

Waste collecting bins colour code

India's urban population of 429 million citizens produce a whopping 62 million tonnes of garbage every year. Out of this, 5.6 million tonnes is the plastic waste, 0.17 million tonnes is the biomedical waste, 7.90 million tonnes is hazardous waste and 15 lakh tonnes is e-waste.

According to an estimate, 40% of municipal waste in the city is 'wet' waste, which can easily be composted and used as manure. Nearly 30% of the municipal waste comprises of plastic and metal, which can be sent to an authorized dealer for recycling, and about 20% of it is e-waste, from which precious metals can be taken apart and recycled. However, out of the total municipal waste collected, 94% is dumped on land and only 5% is composted. To gather the garbage two color bin system was suggested. Green bin for wet waste and blue for dry waste. However, there is a drawback in that system. People do through the sanitary napkins and children's diaper along with wet waste causing the contamination of things. Hence the government has come up with three colored garbage collection bins.

Green Bin

The green coloured bin is used to dump biodegradable waste. This bin could be used to dispose off wet/organic material including cooked food/leftover food, vegetable/ fruit peels, egg shell, rotten eggs, chicken/fish bones, tea bags/coffee grinds, coconut shells and garden waste including fallen leaves/twigs or the puja flowers/garlands will all go into the green bin

Blue bin

The blue coloured bin is used for segregating dry or recyclable left over. This category includes waste like plastic covers, bottles, boxes, cups, toffee wrappers, soap or chocolate wrapper and paper waste including magazines, newspapers, tetra packs, cardboard cartons, pizza boxes or paper cups/plates will have to be thrown into the white bin. Metallic items like tins/cans foil paper and containers and even the dry waste including cosmetics, hair, rubber/ thermocol (polystyrene), old mops/dusters/sponges.

4.5.6 Tricoloured bins

Black bin

Black bin, make up for the third category, which is used for domestic hazardous waste like sanitary napkins, diapers, blades, bandages, CFL, tube light, printer cartridges, broken thermometer, batteries, button cells, expired medicine etc.

5.5.7 Waste Disposal Methods

- Incineration: Combusting waste in a controlled manner to minimize incombustible matter like waste gas and ash.
- Waste Compaction: Waste materials are compacted in blocks and are further sent away for recycling.
- Landfill: Waste that can't be recycled or reused can be thinly spread out in the low-lying areas of the city.
- Composting: Decay of organic material over time by microorganisms.
- Biogas Generation: With the help of fungi, bacteria, and microbes, biodegradable waste is converted to biogas in bio-degradation plants.
- Vermicomposting: Transforming the organic waste into nutrient-rich manure by degradation through worms.

5.5.8 Sources of Waste

1. **Construction waste –** waste coming from construction or demolition of buildings.
2. **Commercial waste-** waste from commercial enterprises
3. **Household waste-** garbage from households is either organic or inorganic
4. **Medical or clinical waste -** wastes from the medical facilities- like used needles and syringes, surgical wastes, blood, wound dressing
5. **Agricultural waste-** Waste generated by agricultural activities that include empty pesticide containers, old silage packages, obsolete medicines, used tires, extra milk, cocoa pods, wheat husks, chemical fertilizers, etc.
6. **Industrial waste-** The waste from manufacturing and processing industries like cement plants, chemical plants, textile, and power plants
7. **Electronic waste-** The defective, non-working electronic appliances are referred to as electronic waste. These are also called e-waste. Some e-waste (such as televisions) contains lead, mercury, and cadmium, which are harmful to humans and the environment
8. **Mining waste-** chemical gases emitted in mine blasting pollutes the environment. And the mining activity greatly alters the environment and nature.
9. **Chemical waste-** waste from the chemical substance is called chemical waste.
10. **Radioactive waste-** radioactive waste includes nuclear reactors, extraction of radioactive materials, and atomic explosions.

5.5.9 Source of Pollution

All these above-mentioned wastes also adds to environmental pollution.

The contaminants that cause detrimental change to the environment are called pollution. It is one of the most serious problems faced by humanity and other life forms on our planet. The earth's physical and biological components have been affected to such an extent that normal environmental processes could not be carried out properly.

5.5.10 Types of Pollution

Types of Pollution	Detail/Pollutants involved
Air pollution	5 Solid particles and gases mixed in the air cause air pollution 6 Pollutants: emissions from the car, factories emitting chemical dust, and pollen
Water pollution	• Water gets polluted when toxic substances enter water bodies such as lakes, rivers, oceans, and so on. They get dissolved in it and cause it unfit for consumption. • Pollutants that contaminate the water are discharges of untreated sewage, and chemical contaminants, release of waste and contaminants into surface
Soil pollution	• It is the presence of toxic chemicals (pollutants or contaminants) in soil, in high enough concentrations to pose a risk to human health and/or the ecosystem • Sources of soil pollution include metals, inorganic ions, and salts (e.g. phosphates, carbonates, sulfates, nitrates),
Noise pollution	• Noise pollution happens when the sound coming from planes, industry or other sources reaches harmful levels • Underwater noise pollution coming from ships has been shown to upset whales' navigation systems and kill other species that depend on the natural underwater world
Light pollution	• Light pollution is the excess amount of light in the night sky. • Light pollution, also called photo pollution, is almost always found in urban areas. • Light pollution can disrupt ecosystems by confusing the distinction between night and day.

UNIT 5.6: Organizations' Focus on the Greening of jobs

Unit Objectives

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

- Understand the concept of ESG
- Explain the different factors of ESG

5.6.1 What is ESG?

The ESG is the short form of environmental, social, and governance. ESG guidelines are used to evaluate businesses on how well they control emissions, governance, human rights, and other factors of their business.

Several companies audit these companies for ESG compliance. They will let the companies know how well the ESG policies are implemented in their company hat let companies know how well their ESG policy is working.

Every business enterprise is deeply intertwined with Environmental, Social, and Governance (ESG) issues. ESG has been looked at seriously by the corporate, government establishments and stakeholders.

ESG is important as it creates high value, drives long-term returns, and global stakeholders are paying attention to the topic.

ESG is said to have created high value, and focuses on long-term returns, and stakeholders are focusing more on this concept.

5.6.2 Factors of ESG

Several factors are used to determine how well a business is doing in maintaining its ESG policies. For creating the ESG Policy, thorough knowledge of these factors are critical.

The factors are divided into three categories; environmental, social, and governance. Knowing about these factors come a long way in designing the effective ESG policy.

Environmental

Environmental factors relate to a business's impact on the environment. Examples include:

- Usage of renewable energy
- Effective waste management
- Policies for protecting and preserving the environment

Social

Social factors relate to the people of the organization. How they are treated in the organization is what it focuses on. The major entities are the stakeholders, employees, and customers. Examples include:

- diversity and inclusion
- proper work conditions and labor standards
- relationships with the community

Governance

Governance factors relate to the company policies for effectively running it. They include:

1. tax strategies
2. structure of the company
3. relationship with stakeholders
4. payments to the employees and CEO

Every factor is important and matters a lot to the overall rating of the company in ESG compliance. Ignoring one aspect in favor of another can affect the rating and in turn the reputation of the company.

The companies make a clear communication about these policies to all the employees, and to the public, they should mention what their various activities are that will protect the environment, people, and the governing factors.

Exercise

1. ESG stand for _____, _____, _____.
2. Governance factors include _____, _____, _____, _____.
3. The three causes of air pollution _____, _____ and _____.
4. Mining waste includes_____.
5. Landfill is a _____.
6. _____,_____ and _____ coloured bins are used for disposing the waste.
7. The plastics cans are trashed in _____coloured bin.
8. _____,_____and _____ are considered as e-Waste
9. _____ part of e-waste is recycled and used again
10. **E-waste is made up of hazardous substances like _____,_____,_____ and _____**

Notes

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6. Communication and Interpersonal Skills

Telecom Sector Skill Council

Unit 6.1 - Interaction with Supervisor, Peers, Customers and Differently abled persons
Unit 6.2 – Explain the importance of developing sensitivity towards Differently abled people

Key Learning Outcomes

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

- Understand what is communication and the importance of communication in the workplace
- Understand effective communication and communicate effectively for success
- Discuss types of communication -verbal and non-verbal
- Communicate at workplace
- Communicate effectively with superiors
- Communicate effectively with colleagues and customers using different modes viz face-to face, telephonic and email communication
- Understand the hurdles for effective communication
- Conduct professionally at work place
- Respect differences in gender and ability
- Communicate effectively with person with disabilities
- Respect for disabled people

Unit 6.1: Interaction with Supervisor, Peers, Customers and Differently abled persons

Unit Objectives

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

- Understand the importance of communication
- Understand types of communication

6.1.1 Why is Communication Important?

- Communication Skills are more important than ever, for all fields of endeavor.
- Whatever the role a person is holding in the organization, having a firm grasp of effective communication will undoubtedly be a key role in the individual's as well as the organization's success
- Oftentimes, people with excellent technical skills don't get promoted to higher roles because of their inability to communicate effectively
- Hence one fundamental skill everybody should be proficient along with the technical skill is Communication Skills
- Effective communication help us to build rapport with the customer both internal and external and help us resolve issues and conflicts easily and quickly.

6.1.2 What is Communication?

3. Communication is the process of sending and receiving information among people.
4. It is imparting or exchanging of information by speaking, writing, or using some other medium
5. The purpose of communication is to convey your thoughts and opinions to others.
6. Communication is said to be successful only when both the sender and the receiver perceive it in the same way.
7. In your personal and professional life, you would be communicating with the following people-
    - Colleagues
    - Customers
    - Friends
    - Parents
    - Relatives

6.1.3 Effective Communication

Effective communication is the process of delivering messages to a target audience in a way that guarantees satisfactory reception and understanding. If the communication is effective, both the sender and the receiver will share the same information at the end of the process. Effective communication is about more than just exchanging information. It's about understanding the emotion and intentions behind the information

6.1.4 Effective Communication for Success

Effective Communication is critical to a business's success. From top to bottom, among colleagues, from subordinates to superiors, and from the organization to the outside, several messages are delivered daily. All the people must communicate these messages properly. Content, language, remarks, tone of voice, and non-verbal communication are elements that affect the effectiveness of messages

Clear and effective communication will

- Increase customer satisfaction
- Bring more business to the company
- Increase productivity among team members

6.1.5 Types of Communication

Communication has been divided into two types:-

- Verbal Communication
- Non-Verbal Communication

Verbal communication takes place when people exchange words with each other, either spoken or written. It includes the choice and use of words and language to convey a message. Examples of verbal communication are face-to-face conversation, telephonic conversation, and a speech or presentation.

Speech

Face to face communication

Phone conversation

Voice chat over internet

Newspapers, e-mails, etc.

Speech has certain characteristics which will affect the message that is being spoken:

- Volume – loud speech may sound bossy, very quiet speech cannot be heard.
- Tone – use warm tones without sounding over-friendly. Cool tones are very unwelcoming.
- Pace – fast speech is not easy to follow. Speak at a reasonable pace so that the other person has a chance to understand.

Click/Scan to understand types of communication

Correct body language also plays an important role in effective communication. For example, a warm smile accompanying 'Have a nice day' or looking directly at the person who is being spoken to give a positive image of the organisation.

Non –Verbal Communication

Non-verbal communication includes the overall body language of a person. There are two kinds of non-verbal communication:

- **Signs and symbols:** for example pictures, or notices, or signboards, or even photographs, sketches and paintings. Here are some examples of different signs and symbols:

- **Gestures and expressions:** hand signs, facial expressions, body postures or body language that can help to convey a message. You can learn to communicate better with others if you learn to recognise some of these.

  Facial expressions - A smile or a frown

  Gestures - movements of hands and body to help explain or emphasize the verbal message

  Body posture - how we stand or sit. Maintain a good posture. When you are talking to a colleague or guest, remember to stand up straight, look professional and be positive. Do not slouch, lean against something or fidget with equipment or your hands.

  Orientation - whether we face the other person or turn away

  Eye contact - whether we look at the other person and for how long

  Proximity - the distance we are from a person

  Head nods - for encouragement, indication of agreement or disagreement

  Appearance - dress and grooming

  Non-verbal aspects of speech - tone and pitch of voice

These non-verbal clues are important as they can be used to improve the quality of communication. They can be used to reinforce any verbal communication; for example, leaning forward and looking at the person you are speaking to and smiling naturally. Your expressions, posture and appearance must be appropriate and should tell the guest that you are professional, competent and willing to help.

6.1.6 Communication at Workplace

In every situation, while interacting with people, we make use of both verbal and Non-Verbal Communication. It is the key to the success of any organization. Be it communication with customers, supervisors, or peers. In today's scenario having technical skills alone is not enough to get the work done, but communication skill is also equally important. Completing the task must require the support of the whole team, and without proper communication, it cannot happen. Effective Communication helps managers to perform their jobs and responsibilities and it serves as a foundation for planning.

6.1.7 Communication with Supervisors

Effective and open communication within a team will build a common purpose among team members that will allow them to reach their goals. Team leaders know that group communication enhances organizational efficiency. The team members should always follow the communication guidelines. Some of the points to remember while interacting with supervisors:

- Be aware of the communication guidelines of the organization.
- Understand and interpret clearly, the work requirements from the supervisor.
- Keep the supervisor informed about the progress of the task assigned.
- Participate in all the discussions which call for decision-making, and provide facts and figures
- Give/ accept suggestions during the discussions.
- Accept the feedback positively and work towards rectifying errors if any. Make sure the same mistakes are not repeated.

6.1.8 Communication with Colleagues & Customers

- The main responsibility is to handle customers' concerns
- Interaction with colleagues/peers is also equally essential and it enhances productivity in the workplace.
- Be polite in speaking to your peers at the office.
- Value other people's time as much as you value your own.
- Before you begin discussing something, ask your co-worker if it is the right time to talk, and give a true picture of how much time you expect to take. Always start the conversation
- Communication with colleagues/customers can be through face-to-face, telephonic, or email.
- Keeping a few points in mind while communicating will make the interaction pleasant and fruitful.

Click/Scan the QR Code to know more about Communication with Colleagues and Customers

6.1.9 Face-to-face Communication

This is an important medium of oral communication, wherein two or more persons talk to each other and see each other physically. This form of communication is direct or straight. Things to remember while you are communicating face to face

- Adjust the tone of voice, don't be too loud
- Make eye contact
- Use appropriate language
- Maintain adequate distance
- Acknowledge, nod during interaction
- Use appropriate non-verbal gestures to communicate with persons with disabilities

Benefits of face-to-face communication

- Instant feedback
- Information conveyed clearly
- Build rapport

6.1.10 Telephonic Communication

Another widely adopted mode of communication is through the telephone. This is the person-to-person conversation where nobody sees others but hears each other and interacts instantly. Nowadays mobile phones are becoming more popular along with landlines as a mechanical media of oral communication.

The following suggestions are recommended to follow while making telephone calls-

- Make the call at the appropriate time
- Provide details about your identity like name, company, department, etc.
- Discuss the purpose of the call
- Think about the tone of your voice
- Listen carefully
- Speak clearly
- If you don't understand something, ask
- Use please, thank you, sorry wherever necessary
- Follow the organization's policies and procedures while interacting on the telephone

6.1.11 Email Communication

Email or Electronic mail is a method of exchanging messages using electronic media. The official or business communication between colleagues or inter-department communication usually happens through email. The advantage of email is you can send communication to many people at the same time.

Points to remember in email communication

- Be clear and concise
- Keep the content short and to the point

- Avoid using jargon and short forms
- Re-read the message, before sending it for grammar and spelling mistakes
- The subject line should describe the main mail content
- Use readable font size (don't keep it too small)
- Add signature at the bottom of the mail body
- Check the attachments for viruses before sending

6.1.12 Importance of timely completion of tasks

Time is a major factor that evaluates the success or failure of a project. Even when the whole team has done a wonderful job and produced high-quality results, with half the cost allotted to the project, everything will be a waste if it was not delivered on time. Any deviation from the timeline will call for a penalty and sometimes may result in losing the project and eventually the customer. so adhering to the timeline is important when it comes to any organization who are into products and services.

Benefits of adhering to timelines:

- Increased and improved customer satisfaction
- Increased productivity and efficiency of the individual
- Team feels motivated
- Sense of adhering to the SLA's and Standard Operating Procedures
- Shows the commitment toward the work and the organization
- Good word of mouth from the customers

6.1.13 Standard Operating Procedure

A Standard Operating Procedure (SOP) is a standardized process that outlines a set of detailed instructions to help workers perform complex tasks properly and safely. The main objective of standard operating procedures is to develop an effective quality system and comply with industry- specific regulations and standards. Failure to follow SOPs can cause significant errors in operations and services.

For a mobile repairing center, the SOP defines the different process of operations, namely handling customer, repairs, sales and interaction among the staff within the repair center.

SOP also clearly defines the responsibility of each and every designated person in the organisation and what is expected from them. It further defines what the various levels of engineers will handle with respect to the handsets coming for repair.

The escalation matrix specifies how the different levels escalate the issue to the next level and adhere to the timelines for repair and communication to the customer.

SOP is created keeping in mind the customer satisfaction as a main motive.

Each and every person in the organisation is expected to read the SOP thoroughly and work accordingly. Because every customer when they go for purchasing a product, one of the main things they see is the post-sales Support. If they find the brands deliver good service support then they don't mind even spending few extra moneys.

Click/Scan the QR Code to know more about telephone communication

6.1.14 Escalation Matrix

Escalation matrix is made up of several levels of contact based on the specific problem at hand. This is being followed by all who are working on that product and have to adhere to the service guidelines. And the problem has to be closed at a minimum turnaround time, and for any reason the repair is taking time proper reason has to be mentioned and notified to all the people concerned including the customer.

6.1.15 Escalation Mechanism

Customer service is a very important aspect of a typical service industry. Giving committed service to customers every time and on time is very crucial for the success of the brand. In recent times, customers do research on how the after-sales support of a product is, and based on that rating they will decide which brand to buy. If the customer service is not good, they will not go for that product even though the product is very good. Hence customer service is a second important aspect of a product and services organization.

For electrical home appliances, the customer logs a complaint and the service engineer is sent to the site for looking into the problem and repairing.

For electronic devices like mobile phones and tablets, the customer is expected to take the product to their service center to get it checked and repaired.

The resolution time matters a lot, as mobile phones have become an indispensable device for people. Their business cannot function without that. Hence too much downtime is also not good. Once at the service center, the technicians at L1 level look for the problem and try to resolve it. If it's beyond their area of resolution the same is escalated to the next level. Every organization has Standard Operating Procedures clearly state the workflow for the repair of the smart phones. Every individual working there must be aware of the same and adhere to the deadline for faster service and enriched customer satisfaction.

6.1.16 Escalation through CRM

Customer Relationship Management is a software, through which most of these companies who are into customer service, manage their customers. The customer details are entered in the system and also the services which are logged against a particular customer. This is the automated system, which takes a particular action after a period of time. For example, if a service request is assigned to an engineer for rectifying a problem of a client, and if the engineer does not update the status of the service in the system within a specified period of time, the problem is automatically escalated to the next level for resolution. Then the new engineer who is responsible for resolving pick it and try to find a solution. This system helps to maintain a track of a particular problem and the current status which will help the organization in effectively managing the customer queries. The complete escalation route is mentioned in the SOP and the same is implemented through the CRM software. This eases the manual escalation procedure which is time consuming and slow.

6.1.17 Escalation Issues at Work

Whether an issue arises among team members or with customers, sometimes the severity of the circumstance requires an escalation to management. Understanding how to approach an escalation can help you better find a solution when conflicts arise. We explore what it means to escalate an issue in the workplace and provide tips for how to do so successfully.

What does it mean to escalate an issue at work?

Escalating an issue in the workplace is the process of bypassing those involved by contacting upper/ senior management. It involves raising awareness of the context to the right people in order to resolve a chal-lenging situation. Typically, escalation occurs when there is an issue that the current staff working on the problem can't resolve and requires assistance from those with more authority and resources

When should you escalate an issue at work?

Deciding when to escalate an issue depends on the amount of risk it can bring to the company. Because escalating an issue can lead to difficult meetings and cause disruptions in work, you should reserve them for issues that truly require escalation. You can often avoid escalating an issue by solving the problem with the individual first.

However, some issues require support from those with higher authority. Consider escalating an issue at work when:

- You have already tried other strategies but that did not work.
- Resolving may incur additional cost to the company or the customer, while rectifying the
- problem.
- Because of the non-availability of certain parts the repair work is taking longer than usual.
- The engineer broke another part while repairing a part. So escalation is required to get the approval to replace the broken part by the company.

6.1.18 Hurdles for Effective Communication

Following are factors contribute to communication not being effective.

Stress and out-of-control emotion. When you are stressed or emotionally disturbed, you're more likely to misread other people and send confusing non-verbal signals. Calm down before continuing the conversation.

Lack of focus. You can't communicate effectively when you're multitasking. If you're checking your phone, planning what you're going to say next, or daydreaming, you're almost certain to miss nonverbal cues in the conversation. To communicate effectively, you need to avoid distractions and stay focused.

Inconsistent body language. Nonverbal communication should support what is being said, not contradict it. If you say one thing, but your body language says something else, your listener will likely feel that you're being dishonest. For example, you can't say "yes" while shaking your head no.

Negative body language. If you disagree with or dislike what's being said, you might use negative body language to ignore the other person's message, such as crossing your arms, avoiding eye contact, or tapping your feet. You don't have to agree with, or even like what's being said, but to communicate effectively and not put the other person on the defensive, it's important to avoid sending negative signals.

6.1.19 Professional Conduct

There are six basic rules to be followed for professional conduct:

- **Be on time:** Being late impedes a company's operations and demonstrates a lack of consideration of the time concerns of others. If you are constantly late for work, meetings, or are always late with your reports and other tasks; it demonstrates to others that you are probably not executive material because you disregard the value of time.
- **Be discreet:** Keep company secrets such as new product designs, sales figures or any other confidences to yourself.
- **Be courteous, pleasant, and positive:** No matter how demanding your clients, customers, co-workers or employees might be; always remain upbeat and positive. Projecting a positive company image has the same effect.
- **Be concerned with others, not just yourself:** Finding out a customer or client's point of view naturally helps you get ahead in any industry. Concern for others should include your superiors, co-workers and subordinates as well.
- **Dress appropriately:** Dress to be comfortable in your environment. Dressing poorly or too casually does not convey a good image, neither does overdressing, which breeds suspicion and mistrust, and will be seen as inappropriate.
- **Use proper written and spoken language:** People who can express themselves clearly are at an advantage. This goes beyond using good grammar, proper spelling, and appropriate diction in all your communications; you should also speak and write to the point.

6.1.20 Respect Gender Differences

In any business, be it a small company to a big corporate, the workforce is a mix of both genders. The ratio of men vs. women varies from 70:30 or 60:40. Studies show that business teams with an equal gender mix perform significantly better than male-dominated teams when it comes to both sales and profits. No two women or men are alike and yet at the same time there are some work-related traits that are gender specific. Both men and women approach their work in a different way and deal with many hurdles that come their way. Since they all share the same workspace, every organization has devised a policy as to how they treat the opposite gender at the workplace and what are the implications of any abuses

Some of the points to remember while interacting with female colleagues

- Treat them with respect
- Support them in case they approach you
- Value their opinion and suggestions
- Involve and include the opposite gender in all the discussions

Unit 6.2: Explain the importance of developing sensitivity towards disabled persons

Unit Objectives

At the end of the unit, you will be able to

- Respect differences in gender and ability
- Communicate effectively with person with disabilities
- Respect people with disability at work

6.2.1 Communication with disabled person

A **disability** is any condition that makes it more difficult for a person to do certain tasks or interact with the people around them (socially or materially). These conditions, or defects, may be cognitive, developmental, intellectual, mental, physical, sensory, or a combination of multiple conditions. Defects may be present from birth or can be acquired during a person's lifetime. Often, disabled people are excluded from full participation in any activity." But things are changing, every organization has allotted some percentage of employees from this section of the society. They are also allowed to exhibit their skills in a few jobs which they can perform without putting their life at risk

General tips for communication with disabled people

Keep these points in mind while interacting with people with a hearing problem

1. Speak to them as you would speak to anyone else in a soft and low tone.
2. Respect the person first, not their disability. For example, use the term ‘a person with disability’ rather than ‘a disabled person’.
3. Do not use phrases such as ‘suffers from’ and ‘crippled’ rather the phrase should be ‘people who use a wheelchair’ rather than ‘wheelchair bound.
4. Don’t drag or push a person’s wheelchair, and don’t move their crutches or walking stick without their permission. It has to be in their personal space.
5. When talking to a person who is in a wheelchair, try to sit in such a way you could reach their eye level. This would not strain them much, to lift their head and talk.

6.2.2 Communicating with People with a Hearing Impairment

Keep these points in mind while interacting with people with a hearing problem

- Draw the person's attention before you speak. Give a gentle tap on their shoulder, a wave of some other visual signal to the person's attention
- Stand in front of the person and maintain eye contact
- Don't cover the mouth while talking. They can figure out what is being said by just looking at the lip movement
- Speak at a normal pace don't speak fast or slow
- Choose the words wisely
- Use short sentence
- Be gentle while speaking don't raise the tone

6.2.3 Respect People with Disability

Learn the proper way to act and speak around someone with a disability.

- Do not use offensive or derogatory words like 'handicapped', 'crippled', and retarded etc.
- Don't criticize or blame them. Don't shout at them or use abusive language
- Talk slowly with a low tone. Pause while talking
- Avoid excessive whispering, joking and laughing unnecessarily
- Assuming things about them or their situation.
- Don't make jokes about their condition or be sarcastic
- Don't look down upon them because of their disability
- Appreciate them for their efforts and work, and motivate them to perform better

6.2.4 Safety at Workplace for People with Disability

Disabilities of all types affect employees and can pose various mental or physical challenges. In many situations, a disability may impact the amount of time it takes for an employee to complete a task or get from one part of a facility to another. Some disabilities may be known while others remain unknown to an employer.

Health and safety legislation should not prevent disabled people from finding or staying in employment so it should not be used as an excuse to justify discrimination against them.

Disabled people and those with health conditions, including mental health conditions, should be given the opportunity to both get into and stay in work.

Responsibilities of an employer towards disabled people

The employer is responsible for the health, safety and welfare of all of their employees, whether they have a disability or not.

Disability is not always obvious so one might not realise a worker is disabled or they might choose not to tell you, particularly if their disability has no impact on their ability to do their job.

Workers do not have to tell anybody unless they have a disability that could foreseeably affect the safety of themselves or anyone else connected to their work. If they do not reveal and there are no obvious indicators of any disability, then the organization are not under any obligation to make workplace adjustments.

Periodically, consult with the employees (whether directly or through their representatives) on issues relating to health and safety. These discussions reflect good safety practice because employees have day-to-day understanding of the job, so they are likely to have good ideas on keeping themselves and others safe.

6.2.5 Workplace Adaptations for People with Disability

Few changes in the workplace to make it a safe place for the disable people will go a long way in the employee satisfaction for an organisation.

Workplace Adaptations

Workplace should be easily accessible for these people with special needs. One major compliance concern deals with accessibility. For example, if workplaces have been adjusted or created more accessible entrances and exits to their facilities, allowing more independence for persons in wheelchairs, would be a great idea. Other subtle changes may include the width of bathroom stalls, hand rails inside the stalls and long ramps instead of stairs. The path of travel that employees take should never be obstructed; there should be no barriers to prevent someone from getting to safety in an emergency.

Workstations easily can be adapted to follow this universal design. Many companies now use slide- out keyboard trays and monitors on swinging arms to allow employees to adjust to their needs.

Desks can accommodate wheelchairs in place of regular chairs, and general work spaces can be lowered to allow easier access. The main goal is to remove all barriers and allow everyone to concentrate more on completing their tasks.

The biggest challenge with universal design is accommodating the multitude of challenges that different disabilities present. Not all disabilities are the same, and not all will present the same challenges for employees. Some employees may have issues with their right hand while others have issues with their left. For some, it may involve not being able to stand or sit. Some may need low lighting, while others need bright lighting. Designing a facility to accommodate all is always going to be a challenge.

Complying with government guidelines can be more difficult in regards to employees with disabilities. This difficulty lies with ensuring that employees are aware of all hazards in the workplace. Multiple disabilities will create multiple reasons that may keep employees from recognizing hazards. Employees with impaired vision, for example, must have other means of identifying hazards. This may be remedied with audible alarms or touch-activated devices that warn employees not to go in an area. Other employees may have difficulties reading and may benefit from shapes or colors to further identify hazardous areas. For workers who lack hearing ability, employers can utilize signs to demonstrate hazards or use flashing strobes to identify when employees need to evacuate an area and head to safety.

Every organization has to make few adaptations in order to make it a better place to work even for people with disabilities. It should provide an environment where they feel they are safe and can carry out their work rather than worrying about their safety.

Exercise

1. What are the three points you will focus on when you talk to people face to face?

   _____

   _____

   _____

Fill in the blanks

1. Before sending the mail it's important to check the _____and of the content.
2. When you interact through phone, provide your identity details like , _____and ___
3. Add your _____at the bottom of your mail.
4. The Customer Care Executive is mainly responsible for handling _____.

Notes

Annexure

Chapter No.	Unit No.	Topic Name	Page No.	QR Code
2	2.4	10 tips for installing fiber optic cables	62	Click/Scan the QR code to access the related video
1	1.1	What is Fiber-Optic Cable with Full Information	24	Click/Scan the QR code to access the related video
2	2.3	Fiber Optic cable splicing	47	Click/Scan the QR code to access the related video
2	2.2	Optical fiber cables, how do they work?	39	Click/Scan the QR code to access the related video
6	6.2	First Aid Techniques	191	Click/Scan the QR code to access the related video
5	5.3	Handwashing Techniques	200	Click/Scan the QR code to access the related video
6	6.3	CPR	204	Click/Scan the QR code to access the related video
6	6.5	E-waste Management Process	209	Click/Scan the QR code to access the related video
5	5.1	Types of Communication	219	Click/Scan the QR code to access the related video

Annexure (Contd.)

Chapter No.	Unit No.	Topic Name	Page No.	QR Code
5	5.1	Communication with Colleagues and Customers	221	Click/Scan the QR code to access the related video
5	5.1	Telephone Communication	223	Click/Scan the QR code to access the related video
Employability Skills				Click/Scan the QR code to access the related video

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