Skill India
कौशल भारत-कुशल भारत

सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP

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National
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Telecom
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Facilitator Guide



Sector
Tower Technician

Sub-Sector
Passive Infrastructure

Occupation
Operation & Maintenance-Passive Infrastructure

Reference ID: TEL/Q4100, Version 4.0
NSQF Level: 4

Tower Technician

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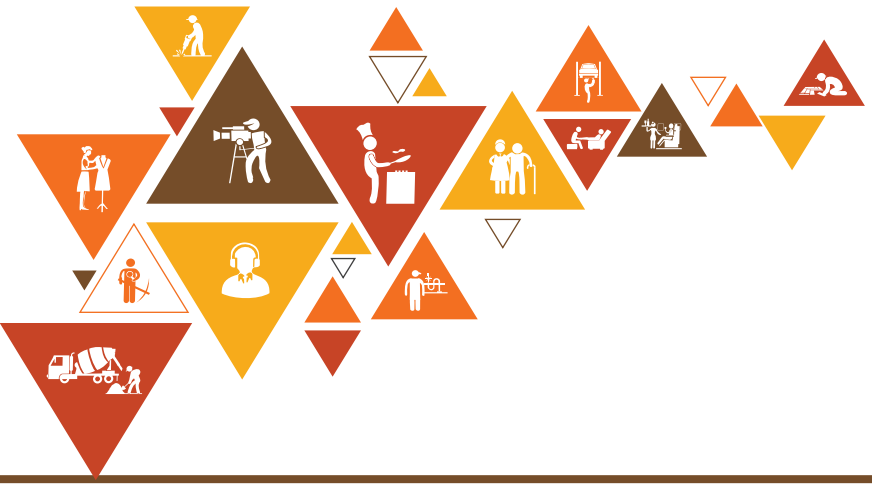


> Skilling is building a better India. If we have to move India towards development then Skill Development should be our mission.

Shri Narendra Modi
Prime Minister of India

Acknowledgement

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

The preparation of this guide 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 facilitator guide is dedicated to the all the aspiring trainers who desire to acquire teaching skills which will be a lifelong asset for their future endeavours.

About this Guide

India is the second-largest telecom market in the world, with over 1.16 billion (116 crores) subscribers, and by 2025 it is expected to grow to 0.95 billion which is (92 crores). The sector employed over 2.2 million (22 lakhs 20) employees directly and 1.8 million(18lakhs) indirectly as of 2021, and it is expected to grow with the introduction of 5G network services. As on date, this sector is in the top five employment opportunity generators in the country.

This Facilitator Guide is designed to help the trainer to effectively conduct sessions to the trainees.

after completing the course the students can work as a Telecom Tower Technician. Individuals at this job, maintains the tower site live at all times, repair level-1 faults, carry out corrective/preventive maintenance at the telecom tower site and report issues to the supervisor. Conducts energy management, estate management-level 1 and verify the assets.

Telecom Tower Technician Qualification Pack (TEL/Q4100) includes the following National Occupational Standards (NOSs):

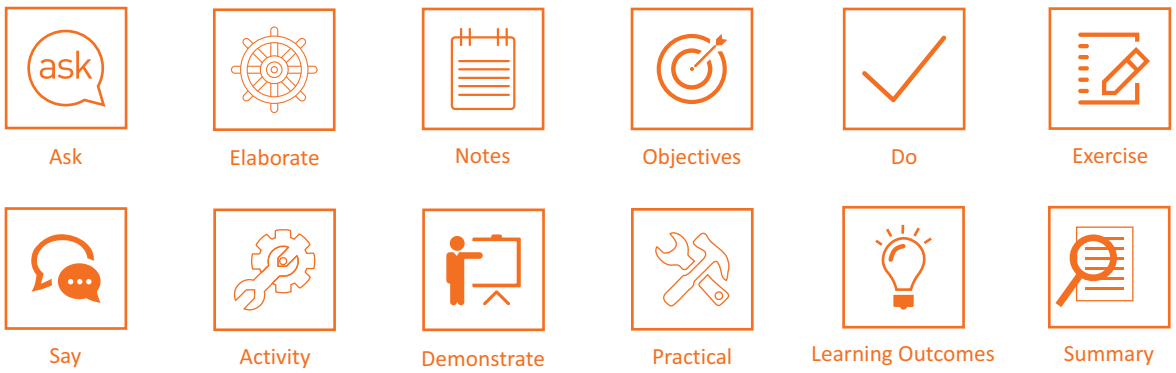
1. TEL/N4138– Maintain the Tower Site and Report Periodically
2. TEL/N4139 – Manage Site Operation Safely and Hygienically
3. TEL/N9101- Organize Work and Resources as Per Health and Safety Standard
4. TEL/N9102 – Interact effectively with Team Members and Customers
5. DGT/VSQ/N0102 Employability Skills (60 Hours)

The Key Learning Outcomes and the skills gained by the par cipant are defined in their respec ve units.

Post this training, the par cipant will be able to keep sites live 24x7 through site maintenance.

We hope that this Facilitator Guide will provide a sound learning support to our young friends to build an a rac ve career in the telecom industry.

Symbols Used



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1. Roles and Responsibilities of a Tower Technician

Unit 1.1 - Introduction to the Telecom Industry

Unit 1.2 - Types of Communication

Unit 1.3 - Types of Cellular Network

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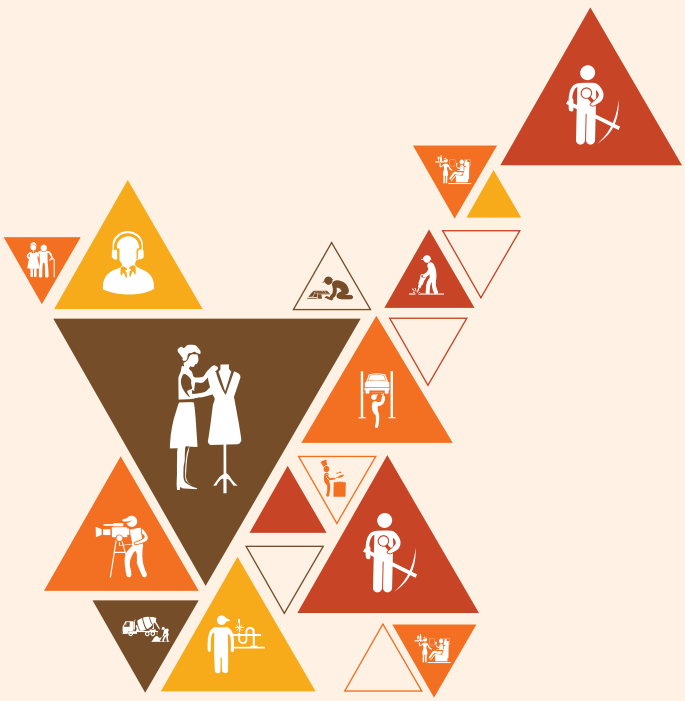

Key Learning Outcomes

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

1. Develop rapport with the participants of the program.
2. Get Introduction of all the participants and let everyone know each other.
3. Share an understanding of the telecom industry.
4. Discuss about communication and types of communication networks.
5. Explain about types of cellular networks and components used in these networks.
6. Discuss about tower Infrastructure industry.
7. Share details about the job role of tower technician and what will be his role and responsibilities.

UNIT 1.1: Icebreaker

Unit Objectives

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

- Get the introduction of the faculty
- Introduce themself with all the fellow students
- Build rapport with other students and the trainer

Resources to be Used

- Available objects such as a duster, pen, notebook etc
- Internet, PC/Laptop and projector

Do

- Make the students stand in a circle, close enough to the person each side of them that they can pass the parcel quickly.
- Say 'Stop' when the students least expect it. The person who has the parcel at that time should get out.
- Those who get out should introduce themselves by providing their names and a little additional information such as favorite hobbies, likes, dislikes etc.
- The winner of the game should stand and introduce himself/herself at the end of the game.

Say

- Thank the students for their participation
- Tell them to please take their seat
- Let's start with your course

Notes for Facilitation

- You could ask the students who get out during the game to be the music keepers. They can start and stop the music as the game progresses.
- Encourage shy students to provide information about themselves by prompting them with questions such as 'what do you enjoy doing the most', 'what is your favorite movie or book' etc.
- This will ensure a healthy bonding in the class and also open up shy students.

UNIT 1.1: Objectives of the Course

Unit Objectives

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

1. Discuss about the telecom industry in India.
2. Identify the technologies being deployed in cellular networks.
3. Gain an overview of tower infrastructure industry in India.
4. Understand the Job role of tower technician and expectation from them.
5. Discuss the components of a cellular networks and bringing the focus on tower site.

Notes for Facilitation

- You could ask the students about the expectations from the course
- Invite students to participate. List their expectations on the whiteboard
- Give the students a brief overview of what all will be covered in the program

UNIT 1.1: Telecom Industry in India

Unit Objectives

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

1. Discuss the evolution and growth of the telecom industry in India.
2. Talk about the future growth which is expected in the industry.
3. Touch upon international scenario of telecom industry.
4. Discuss about the telecom product companies worldwide and in India.
5. Explain how network solution companies are important for telecom operators.

Say

- The global Telecom industry is US $ 670 Billion and market Cap of these Companies is US $ 991 billion. convert this figure in Indian rupees to show them big number. This industry is growing at a CAGR of 15 % annually over the last many years.
- India is the second largest growth markets worldwide after China with more than 1 billion telephone subscribers.
- Talk about Indian telecom operators, discuss a bit about Airtel, Reliance, BSNL etc.
- Give some insight about few top global telecom operators to students.
- Discuss the role of telecom product companies and solution providers in a telecom operator network.

Notes for Facilitation

- You could ask the students what they know about various telecom operators in India. Lead this towards a discussion so that everyone gets a good knowledge about the operators.
- Give students some time to discuss about some global telecom operators, you can name few and let people add more knowledge/ inputs to this.

UNIT 1.2: Types of Communication

Unit Objectives

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

1. Clearly understand the definition of telecommunication.
2. Understand the types of networks used for telecommunications.
3. Differentiate between wireless and wire line communication.

Say

- Definition of telecommunication.
- Lead the discussion in a way where everyone in the class gets a clear idea about the term telecom.
- Telecommunication happens on two types of networks wire line and wireless networks.
- Talk about both these types and explain this in a bit of details.

Ask

- Ask one student to explain what he understands from word telecommunication.
- Ask the students regarding the difference between wireless and wire line communication.
- Ask the students as how the call gets routed between wireless and wire line communication.

UNIT 1.3: Types of Cellular Network

Unit Objectives

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

1. Know about CDMA and GSM networks.
2. Differentiate between 2G, 3G, 4G and 5G networks.
3. Understand the advantages of new technology networks over previous ones.

Say

- Give an overview of GSM and CDMA technology.
- Give an overview of 2G, 3G, 4G, 5G networks.
- Talk about the advantage of the progressive technology enhancement.
- Explain how convergence of CDMA and GSM technology is happening after LTE (Long term evolution) or 4G.
- Explain the new applications like IOT (Internet of Things), which are coming up by adopting latest technologies like 4G and 5G.

Ask

- Ask students to prepare notes on GSM, CDMA, 2G, 3G, 4G and 5G. Take 10 min session in the class. This will create an excellent awareness about technologies in students.
- Ask the students to prepare 10 min session on IOTs and how are they are going to change the world.

UNIT 1.4: Components of Cellular Network

Unit Objectives

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

1. Figure out the components used in a GSM network.
2. Understand the use of a SIM card in a mobile station.
3. Identify the role of a BTS (Base Transceiver Station) in the mobile communication.
4. Explain how internet traffic flows from a mobile station to IWF (Inter working function) and internet.
5. Discuss the use of various databases and how security is implemented.

Say

- Explain the terms related to cellular networks like Mobile Station, Base Station, Gateway, data bases
- Talk about the security mechanism used to prevent unauthorized users from entering the network.
- Elaborate on the types of radio waves used in cellular networks.

Ask

- Ask the students to explain what is mobile station
- Tell them to talk about the mobile switching center
- Ask them questions on how data connectivity is achieved on mobile network.
- Let them explain, how a mobile station gets connected to a base station

UNIT 1.5: Tower Infrastructure Industry

Unit Objectives

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

1. Highlight the need of a tower infrastructure industry and the investment needed in it.
2. Appreciate the reasons of frequent mergers and acquisitions in this industry.
3. Talk about the major companies in this industry in India.
4. Understand the concept of Infrastructure sharing.

Do

- Give an overview of tower infrastructure industry.
- Discuss various companies in India who are part of Tower Infra Industry.
- Talk about some mergers which are happening in this industry and give reasons why.
- Discuss about infrastructure sharing and need of the same.

Ask

- Ask students to find out top three Tower infra companies in India and number of towers they have.
- One student should speak of about infrastructure sharing as to what they understood from this.

Notes for Facilitation

- Faculty should spend some time on internet and google about the topics covered in this unit to get the latest updated information about the topics covered.

UNIT 1.6: Career Progression as Tower Technician

Unit Objectives

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

1. Understand the responsibilities of a tower technician.
2. Get aware of the SLAs which he has to work on.
3. Understand the organizational hierarchy in an tower infrastructure company.
4. Define the growth path for him as a career.

Say

- About the responsibilities of a tower technician.
- That the job role is very critical for continuous working of a cell site.
- That if the cell site goes down the communication gets lost for all the people in that area.

Ask

- Ask few students why they want to become a tower technician.
- Ask the participants to elaborate on the role as to what they think is expected from them

Summarize

In this chapter students have learnt about

- Details of telecom industry.
- Technical details of communication and telecom networks.
- Details about tower infrastructure industry.

Answers to PH Questions

- Descriptive

1. Refer Unit 1 Roles and Responsibilities of Tower Technician
Topic : Unit 1.1 Introduction to the Telecom Industry

2. Refer Unit 1 Roles and Responsibilities of Tower Technician
Topic : Unit 1.1 Introduction to the Telecom Industry

3. 1. Refer Unit 1 Roles and Responsibilities of Tower Technician
Topic : Unit 1.3 Types of Cellular Network

4. Refer Unit 1 Roles and Responsibilities of Tower Technician
Topic : Unit 1.4 Components of a cellular network

5. Refer Unit 1 Roles and Responsibilities of Tower Technician
Topic : Unit 1.5 Tower Infrastructure Industry

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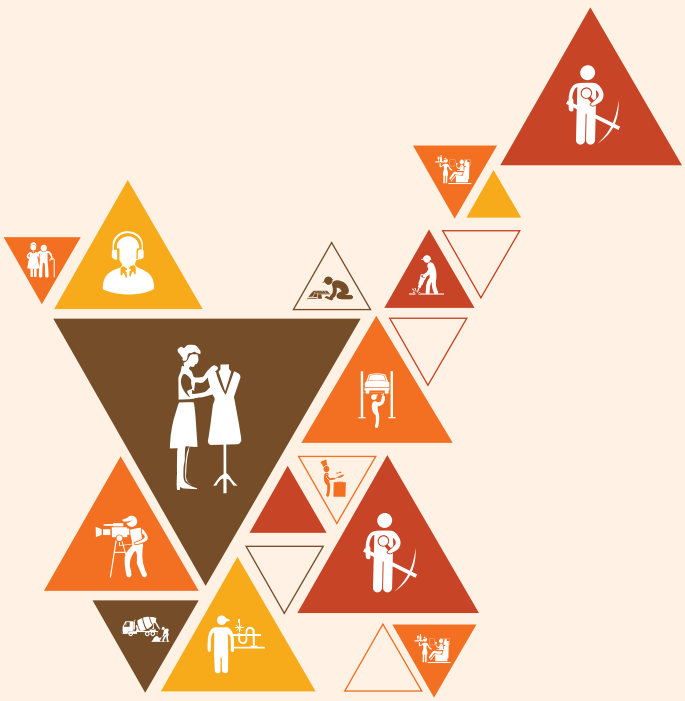
2. Maintain tower site and report periodically



TEL/N4138

Key Learning Outcomes

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

1. Identify the components at a cellular tower site.
2. Know about the Equipments to be maintained at a cellular site.
3. Maintain site hygiene of AC, DG, PIU, SMPS and battery bank, as per organization's norms.
4. Understand other important components at site like Earthing, Lightening Arrester etc.
5. Check if installation of fire safety instruments is in place.
6. Control fire accident incidents.
7. Check the site as per electrical safety norms.
8. Understand Do's and Don'ts at a tower site.
9. Understand the process of site Audit
10. Understand reporting structure
11. maintain records of various format as per company policy and SLAs
12. Escalate faults/issues at site to supervisor
13. Fill the preventive maintenance checklists/reports of all activities at the site
14. Fill the corrective maintenance checklists/reports of all activities at the site

UNIT 2.1: Introduction to Components at a Tower Site

Unit Objectives

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

- Get an overview of various components at a tower site
- Identify and position these components in the telecom tower
- Understand the functioning of each component

Notes for Facilitation

- You could ask the students about their knowledge of a tower site and what are the components present.
- Invite students to participate. Tell them to give a brief description of the components they know.
- Let there be a debate in the class on the functioning of each component.

2.1.1: Components at a Tower Site

Say

- As we move forward it's very important to know about all the components at a tower site
- You should also know about the functioning of each component

Do

- Explain to the participants the need of getting things clear during this session
- Clarify all their doubts
- Ask them to get into pairs for practice.
- Go around and make sure that they are doing it properly.

Activity

- This is a skill practice activity to understand the components of a tower site
- Ask the students to assemble together and form groups. Take them to a tower site to demonstrate the working of the site and make them acquaint with the equipments/ components used at the site
- Encourage students to ask questions, so that they can understand it properly
- Ask the students not to touch any equipment at site
- Details of the skill activity are given below
- Method to do this activity:

Show and explain various components/ equipments at the site, ensure they understand the need of each equipment.

Skill Practice	Time	Resources
To get acquainted with the equipments and components at a tower site	4 hours	Take permission to visit a tower site with participants.

Method to do this activity

- Refer unit 2.1.1, page 16 of the participant handbook
- Discuss all the components given in the participant handbook
- Ensure that student gets a basic overview of these components at a tower site

Activity

- This is a skill practice activity to demonstrate the tools used at a tower site on day to day basis
- Ask the students to assemble together and form groups
- Explain to them what we are going to do in this practical exercise
- Demonstrate and make them acquainted with the functioning of these tools
- Tell all the students to do this activity individually to gain practice
- Details of the skill activity are given below

Skill Practice	Time	Resources
To practice the use of various tools at the tower site, on day to day basis.	4 hours	Batteries, Gloves, Voltmeter, spanners, Cable and Lugs, Jelly, Voltmeter, ammeter, amp-hour meter, hydrometer, screw driver set, hammer

Method to do this activity:

- Take out and display all the tools and meters used at a tower site
- Explain functioning of each tool to participants
- Give them some exercises to use these tools
- Ensure they are able to use these tools as and when at the site

Answers

- Descriptive

1. Refer Unit 2.1 Introduction to components at a Tower Site
Topic : Unit 2.1.1 components at a Tower Site

2. Refer Unit 2.1 Introduction to components at a Tower Site
Topic : Unit 2.1.1 components at a Tower Site

3. Refer Unit 2.1 Introduction to components at a Tower Site
Topic : Unit 2.1.1 components at a Tower Site

UNIT 2.2: Telecom Tower

Unit Objectives

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

1. Understand the steps involved in identifying a telecom tower site.
2. Describe the civil works required for the construction of a site.
3. Explain the important points for the takeover of a site once it is ready.
4. Differentiate between various types of towers used in a telecom networks.

2.2.1: Construction of a Telecom Tower Site

Say

- Welcome and greet the participants.

Do

- Explain the definition and use of a telecom tower.

Ask

- Make few students to stand and ask them the need and use of a telecom tower?

2.2.2: Civil work Scope and Survey

Do

- Talk about the requirements at a site for installation of the tower?
- Organize a group discussion among the participants to identify the points to be looked at while doing survey for the selection of a site.

2.2.3: Site Civil Work Execution and Takeover

Elaborate

Elaborate this activity of site work execution and finally takeover of the site. Talk about the steps involved in creating an engineering drawing of the site based on the specifications of the site. Post completion of civil work like lying of foundation etc fixing of shelters and DG set is done.

2.2.4: Types of Tower Unit

Do

- List the four types of towers used at various sites

Elaborate

- Refer page 20-22 of participant handbook and differentiate between all four types of towers.
- Share specific reasons when a particular type of tower is used
- Talk about the specifications of each tower

Activity

- This is a skill practice activity to demonstrate the specifications of different types of towers used at various tower sites. This activity will provide complete knowledge of various types of towers.
- Ask the students to assemble together and form groups
- Explain to them what we are going to do in this practical exercise
- Ask the students to clarify all their points during this interaction
- Details of the skill activity are given below.

Skill Practice	Time	Resources
To understand different types of towers used at a tower site.	2 hours	Projector, Board, Marker, visit to a tower site

Method to do this activity

1. Display the specification Table 2.2.10 on the page 22 of the participant handbook and explain the specifications to the participants.
2. Discuss questions/queries ,if any.
3. See if you can visit a tower site and show a specific tower to the participants.

2.2.5: Tower Site Takeover

Say

- Once the site is ready it should be verified by the site engineer
- Once certified site is taken over, its ready for the operations

2.2.6: Site Hygiene of a Tower

Say

- Refer Subunit 2.2.6 on page 23 of the participant handbook
- These are few key points which are important for proper upkeep of a tower
- Explain these points to participants as described in the participant handbook

Ask

- If they have any doubts, clarify them

Excercise

- Discuss the questions asked in the participant handbook

Key Learning Outcomes

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

1. Learn about the components at a cellular tower site.
2. Know about the equipments to be maintained at a cellular tower site.
3. Maintain site hygiene of AC, DG, PIU, SMPS and battery bank, as per organization's norms.
4. Understand about other important components at site like Earthing, Lightening arrester etc.
5. Check if installation of fire safety instruments are in place.
6. Control incidents like fire accident.
7. Check the site as per electrical safety norms.
8. Check proper floor markings, shadow board display and labels.
9. Explain Dos and Don'ts at a tower site.
10. Maintain checklist of standards laid by the company based on its knowledge and understanding.

UNIT 2.1: Introduction to Components at a Tower Site

Unit Objectives

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

- Get an overview of various components at a tower site
- Identify and position these components in the telecom tower
- Understand the functioning of each component

Notes for Facilitation

- You could ask the students about their knowledge of a tower site and what are the components present.
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To get acquainted with the equipments and components at a tower site	4 hours	Take permission to visit a tower site with participants.

Method to do this activity

- Refer unit 2.1.1, page 16 of the participant handbook
- Discuss all the components given in the participant handbook
- Ensure that student gets a basic overview of these components at a tower site

Activity

- This is a skill practice activity to demonstrate the tools used at a tower site on day to day basis
- Ask the students to assemble together and form groups
- Explain to them what we are going to do in this practical exercise
- Demonstrate and make them acquainted with the functioning of these tools
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Skill Practice	Time	Resources
To practice the use of various tools at the tower site, on day to day basis.	4 hours	Batteries, Gloves, Voltmeter, spanners, Cable and Lugs, Jelly, Voltmeter, ammeter, amp-hour meter, hydrometer, screw driver set, hammer

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- Take out and display all the tools and meters used at a tower site
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2.2.1: Construction of a Telecom Tower Site

Say

- Welcome and greet the participants.

Do

- Explain the definition and use of a telecom tower.

Ask

- Make few students to stand and ask them the need and use of a telecom tower?

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Do

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2.2.3: Site Civil Work Execution and Takeover

Elaborate

Elaborate this activity of site work execution and finally takeover of the site. Talk about the steps involved in creating an engineering drawing of the site based on the specifications of the site. Post completion of civil work like lying of foundation etc fixing of shelters and DG set is done.

2.2.4: Types of Tower Unit

Do

- List the four types of towers used at various sites

Elaborate

- Refer page 20-22 of participant handbook and differentiate between all four types of towers.
- Share specific reasons when a particular type of tower is used
- Talk about the specifications of each tower

Activity

- This is a skill practice activity to demonstrate the specifications of different types of towers used at various tower sites. This activity will provide complete knowledge of various types of towers.
- Ask the students to assemble together and form groups
- Explain to them what we are going to do in this practical exercise
- Ask the students to clarify all their points during this interaction
- Details of the skill activity are given below.

Skill Practice	Time	Resources
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Method to do this activity

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Say

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- Once certified site is taken over, its ready for the operations

2.2.6: Site Hygiene of a Tower

Say

- Refer Subunit 2.2.6 on page 23 of the participant handbook
- These are few key points which are important for proper upkeep of a tower
- Explain these points to participants as described in the participant handbook

Ask

- If they have any doubts, clarify them

Excercise

- Discuss the questions asked in the participant handbook

UNIT 2.3: Shelter/Room

Unit Objectives

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

1. Discuss the definition of a shelter.
2. Identify the parts of a shelter.
3. Differentiate between different types of shelters.
4. Understand the usages of a shelter.
5. Explain the structure of PUF panel.
6. Maintain the site hygiene for a shelter site.

2.3.1: Shelters

Say

- Shelters provide protection to all the equipments at a tower site from all weathers.
- It provides controlled environment to the equipments deployed at the site.

2.3.2: Types of Shelter

Elaborate

- Refer unit 2.3.2, page 28-29 of the participant handbook
- On two types of shelters used in the telecom industry
- On the material used for construction of pre-fabricated shelters
- On the way they are connected /put together to ensure that they are weather proof

Activity

- This is a skill practice activity to show different types of shelters and to demonstrate the construction/features of shelters . This activity will provide complete knowledge of various shelters at a tower site.
- Ask the students to assemble together and form groups
- Take them to a tower site
- Explain to them what we are going to do in this practical exercise
- Ask the students to clarify all their points during this interaction
- Details of the skill activity are given below.

Skill Practice	Time	Resources
To provide a complete knowledge of various shelters used at a tower site. Also describe all the accessories used in the shelter.	4 hours	Visit to a tower site

Method to do this activity

1. Take the participants to a telecom tower site.
2. Instruct them not to touch any equipment at the site.
3. Any touch may harm them or damage the equipments.
4. Show them the shelter and all the accessories used in a shelter.
5. If this is a pre-fabricated shelter, tell them the way they are connected together.
6. Show the interlocking mechanism which could be either cam lock or tongue or groove joint.
7. Explain the difference between riveted or non riveted shelters.
8. Show all the equipments and accessories used in the shelter to the participants.
9. Give a brief about the functioning of all accessories.
10. Demonstrate the points which are important for maintaining site hygiene.
11. Ask questions from the participants to check their understanding.
12. Answers to their doubts, if they have.

2.3.3: Accessories used in a shelter

Say

- The accessories used in a shelter have specific functions.
- Refer page no 30 of participant handbook and elaborate on the functioning of all various accessories in the shelter.

Ask

- After you have explained about different accessories used in the shelter, ask the students to stand one by one and explain the functions of each accessories used in a shelter.
- If participants have any doubts ask them to clarify their doubts.

2.3.4: Site Hygiene for a Shelter

Say

- Refer subunit 2.3.4, page 31 of the participant handbook.
- Talk about the importance of the site hygiene at a tower site.
- Discuss these points one by one.
- Correlate these details with the observations which participants had during the site visit.

Do

- Ask the participants to clarify their doubts.

2.3.5: Shelter from Inside

Do

- Ask the students to write down the observations from the site visit.
- Based on their observations they should draw the layout of the site.
- They should compare their layout with a recommended layout as shown in Fig 2.3.1, page 32 of participant handbook

Excercise

- Discuss the questions asked in the participant handbook

UNIT 2.4: Power Interface Unit (PIU)

Unit Objectives

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

1. Understand the concept of Power Interface unit (PIU).
2. Know the features of a PIU.
3. Identify the components of a PIU.
4. Explain the functioning of a PIU.
5. Identify Do's and Don'ts of a PIU site.
6. Understand the technical specification of a PIU.

2.4.1: Key features of a PIU

Say

- The definition of a PIU.
- Use of the PIU at a telecom site.

2.4.2: Components of a PIU

Say

- Talk about the basic structure of the PIU.
- Describe the components of the PIU.

Elaborate

- Refer unit 2.4.2, page 35 of the participant handbook.
- Discuss and explain in detail the critical components of a PIU.

Ask

- If participants have understood the points being shared

2.4.3: Block Diagram of a PIU

Do

- Refer fig 2.4.9, page 27 of the participant handbook.
- Ask one student to come up and draw the block diagram of PIU on the Board.
- Tell him to describe the uses of a PIU .
- Explain the functioning of each components in detail
- Explain about the AMF (Auto Main Failure) or change over in detail.

Ask

- Ask the participants whether they have understood the concept.

2.4.4: Site Hygiene Requirements of a PIU

Say

- Discuss site hygiene conditions of a PIU
- Do's at a PIU site
- Don't at a PIU site

2.4.5: Technical Details of a PIU

Do

- Refer page 39-41 and display the technical specification diagram of a PIU
- Discuss important parameters with the participants

Ask

- Ask the participants to complete the practical and exercise as given in the participant handbook.
- Ask the students to clarify their doubts ,if any.

Activity

- This is a skill practice activity to demonstrate the key components and functioning of a PIU. This activity will provide complete understanding of the working of a PIU
- Ask the students to assemble together and groups
- Explain to them what we are going to do in this practical exercise
- Ask the students to clarify their points during this interaction
- Details of the skill activity are given below.

Skill Practice	Time	Resources
To understand the key component and functioning of a PIU.	3 hours	PIU which can be opened for demonstration to the participants.

Method to do this activity

1. Refer unit 2.4, page 34-42 and various diagrams shown in the unit of participant handbook
2. Take the students in front of a PIU and demonstrate various components to the students
3. Show them all the hygiene guidelines which they have to follow
4. Refer unit 2.4.5 and describe all the technical specification practically to the participants

UNIT 2.5: Battery Bank

Unit Objectives

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

1. Understand the concept of a battery bank.
2. Differentiate between a cell and a battery.
3. Know about the types of batteries used.
4. Understand the working of the Lead acid batteries.
5. Differentiate between types of lead acid batteries.
6. Select the right capacity of VRLA battery needed for site.
7. Understand the need of the site hygiene for a battery bank.
8. Know about the do's and don'ts of a battery bank.

2.5.1: A Cell and a Battery

Say

- Refer page 44 of the participant handbook and discuss the definition of a cell and of a battery
- Draw diagrams of a battery and a cell and explain the concept of polarities
- Explain how the flow of electrons is linked to movement of current in a cell.

2.5.2: Types of Battery

Say

- Tell the difference between primary and secondary batteries.
- Discuss on various types of batteries with examples.

2.5.3: Lead Acid Battery

Say

- Elaborate on the history of the Lead Acid Battery
- Talk about various types of Lead Acid Batteries, refer pages 43-48 of the participant handbook:
  a. Open flooded battery
  b. SMF
  c. SMF VRLA: These are available in two types GEL and AGM batteries which are explained below.

  1. GEL battery is a lead-acid electric storage battery which
     - Is sealed using special pressure valves and should never be opened.
     - Is completely maintenance-free.
     - Uses thixo tropic GEL electrolyte.
     - Uses a recombination reaction to prevent the escape of hydrogen and oxygen gases.
     - Have more electrolyte(15~20% more than VRLA) to ensure long life.
     - Is non-spill able, and therefore can be operated in virtually any position. However, upside-down installation is not recommended.

  2 AGM (Absorbed Glass Material) battery is a lead-acid electric storage battery which:
     - Is sealed using special pressure valves and should never be opened.
     - Is completely maintenance-free.
     - Have electrolyte absorbed in separator's (70~80%) and plate's((20~30%)) microspore.
     - Uses a recombination reaction to prevent the escape of hydrogen and oxygen gases, normally lost in a flooded lead-acid battery (particularly in deep cycle applications).
     - Is non-spill able and therefore can be operated in virtually any position. However, upside-down installation is not recommended.

  Describe the difference between GEL and AGM batteries:
     - Both are recombinant batteries.
     - Both are sealed VRLA battery.
     - AGM batteries and GEL batteries, both are considered “acid-starved”.
     - In an AGM and GEL battery, the electrolyte does not flow like a normal liquid.
     - In a GEL battery, the electrolyte has the consistency and appearance of jelly. Like gelled electrolyte batteries, absorbed electrolyte batteries are also considered non-spill able – all of the liquid electrolyte is trapped in the sponge-like matted glass fiber separator material. The “acid-starved” condition of GEL and AGM batteries protects the plates during heavy deep-discharges. The GEL battery is more starved, giving more protection to the plate; therefore, it is better suited for super deep discharge applications.
     - Due to the physical properties of the gelled electrolyte, GEL battery power declines faster than an AGM battery's as the temperature drops below 32ºF. AGM batteries excel for high current, high power applications and in extremely cold environments.

Elaborate

- On the working of a lead acid battery refer section 2.5.3 and 2.5.4 of the participant handbook.
- On charged state, discharged state and overcharged state.
- On how to measure a charged state of a battery – Refer to figure 2.5.1 (shows the method of checking the specific gravity value of the battery and its relationship with the % of charging of the battery.

Fig. 2.5.1 Battery Charge Measurement

Refer to figure 2.5.2 and 2.5.3 below, this shows the relationship between the battery charging voltage/Specific gravity value and the charging %. Explain this to the participants so that they can understand this relationship.

Specific Gravity Value	Charging %
1.265 to 1.275	100%
1.225 to 1.235	75%
1.190 to 1.200	50%
1.155 to 1.165	25%
1.120 to 1.130	0% charging required

Fig. 2.5.2 Specific Gravity Value V/S Charging %

Battery charging voltage	Charging %
12.60	100%
12.45	75%
12.30	50%
12.15	25% Charging Required

Fig. 2.5.3 Battery Charging Voltage V/S Charging %

Activity

- This is a skill practice activity to measure the specific gravity of a battery.
- Ask the students to assemble together and groups.
- Explain to them that we are going to do a practical exercise.
- Please ensure that since the hydrometer will carry electrolyte which is an acid, special precaution need to be taken to ensure that no participant gets acid burn.
- Details of the skill activity are given below.
- Ask the students to do this activity separately and gain practice.
- Each participant should gain experience of doing this activity.

Skill Practice	Time	Resources
Measuring specific gravity of a Battery	2 hours	Battery, Hydrometer, Gloves, eye protection gear

Method to do this activity

1. Put on eye protection and rubber gloves.
2. It is recommended to disconnect the battery especially if on a high rate of charge / discharge.
3. Remove vent cap.
4. Carefully draw liquid into the hydrometer and avoid "bumping" the hydrometer.
5. Obtain a reading by looking directly at the float.
6. Compare the reading with the chart shown above.
7. Repeat steps 3-5 to reconfirm reading.
8. Record the cell number and result.
9. If it is very warm or very cold, correct the specific gravity at given temperature. If the ambient temperature is fairly consistent and original gravities are taken when the batteries are put into service, temperature correction is not critical and is only necessary when problems arise. Make sure that electrolyte is not hot, when taken out of service. Let it to reach at the room temperature.

2.5.4: Types of Lead Acid Batteries

Say

1. There are three types of Lead Acid Batteries as explained in earlier section:
   - Open type battery
   - Sealed maintenance free (SMF) battery
   - SMF – VLRA (Valve Regulated Lead Acid) battery
2. Explain all three types of batteries
3. Show the differences between three batteries.

Ask

- If participants have understood these differences
- Clarify their doubts, if any

Activity

- This is a skill practice activity to check the water level in an open type battery and filling water incase level is less.
- Ask the students to assemble together and form groups.
- Explain to them that we are going to do a practical exercise on filling water in battery.
- Please ensure that since we might get in touch with electrolyte which is an acid, special precaution need to be taken to ensure that no participant gets acid burn.

- Ask the students to do this activity separately and gain practice.
- Details of the skill activity are given below.

Skill Practice	Time	Resources
Checking water level in a Battery	2 hours	Battery, Gloves, Distilled water, Funnel, turkey baster

Method to do this activity:

- (Refer to Figure 2.5.4 on next page) open the covers of the cells (vent cap) of the open type battery.
- Through a torch check the level of water in individual cells.
- If the level of water is about 1 cm above the plates its fine.
- If the level is lower than this, you need to fill in distilled water in individual cells.
- Fill in water in the turkey baster and through a funnel add water to the cells.
- Checks the water levels again in the cell, if it's less, add more.
- Don't use the tap water otherwise minerals will get added to battery thus starting a chemical reactions in the cell.
- If it's fine, close the covers of the cell to prevent flow of gases in the atmosphere.
- Clean the battery and its ready for use again.

Explain

Watering:

Watering is the single most important step in maintaining a flooded lead acid battery; a requirement that is all too often neglected. The frequency of watering depends on usage, charge method and operating temperature. Over-charging also leads to water consumption.

A new battery should be checked every few weeks to estimate the watering requirement. This assures that the top of the plates are never exposed. A naked plate will sustain irreversible damage through oxidation, leading to reduced capacity and lower performance.

If low on electrolyte, immediately fill the battery with distilled or de-ionized water. Tap water may be acceptable in some regions. Do not fill to the correct level before charging as this could cause an overflow during charging. Always top up to the desired level after charging. Never add electrolyte as this would upset the specific gravity and promote corrosion. Watering systems eliminate low electrolyte levels by automatically adding the right amount of water.

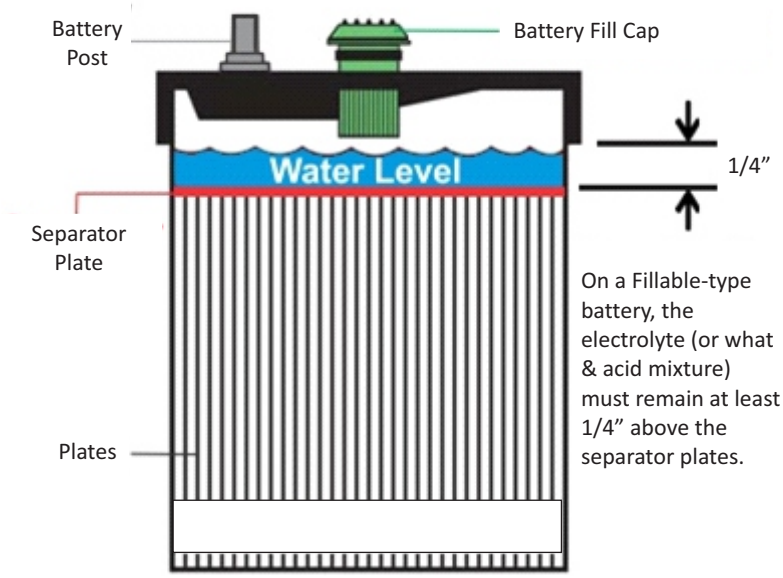


Fig. 2.5.4 Battery Water Level

2.5.5: Specification of a Lead Battery

Do

- Go to the board and write down all the key characteristics of the battery.

Elaborate

Refer Unit 2.5.5, page 49 of the participant handbook and explain/clarify all the points mentioned there as they form specifications of a battery. Few major points can be explained as below.

While our VRLA batteries accept a charge extremely well due to their low internal resistance, any battery will be damaged by continual under-or overcharging. Capacity is reduced and life is shortened.

Overcharging is especially harmful to any VRLA battery because of the sealed design. Overcharging dries out the electrolyte by driving the oxygen and hydrogen out of the battery through the pressure relief valves. Performance and life gets reduced. If a battery is continually undercharged, a power-robbing layer of sulfate will build up on the negative and positive plates, which acts as a barrier to recharging. Over discharge and Premature shedding can occur. Thus performance gets reduced and life of a battery is shortened.

WARNING-Never leave a VRLA battery in a discharged state:
When a battery is left in a discharged state for prolonged periods of storage, lead sulphate crystals begin to form acting as a barrier to recharge and will prevent normal battery operation. Depending on the degree of sulphate, a battery may be recovered from the condition by constant current charging at a higher voltage with the current limited to one tenth of the battery capacity for 12h or longer. This is called Boost Charging. In extreme circumstances a battery may never fully recover from sulphate and must be replaced.

Thus the charger must be temperature-compensated to prevent under or overcharging due to ambient temperature changes.

Rate of Discharge

Minutes discharged at 50, 25, 15, 8 and 5 Amperes
Minutes discharged is the time in minutes that a new, fully charged battery will deliver at various currents and maintain at least 1.75 volts per cell. These are nominal or average ratings.

Ampere Hour Capacity C20, C3, C1 etc
These are nominal or average ratings. Ampere Hour Capacity is an expression describing rate of discharge. The number indicates the number of hours to completely discharge the battery at a constant current. So C/20 is the current draw at which the battery will last for 20 hours (C20), C/1 is the current at which the battery will last 1 hour (C1). The useful capacity of a battery changes depending on the discharge rate, so battery capacities are stated with respect to a particular rate. For instance, a particular model of our battery CJ12-40 is rated at 40 amp-hours at the C/10 rate of 4.0 amps, but only 26 Ah at the C/1 rate of 26A.

Example
10 amperes for 20 hours (10 x 20) = 200 Ah @ the 20-hour rate(C20)
8 amperes for 3 hours (8 x 3) = 24 Ah @ the 3-hour rate(C3)
30 amperes for 1 hour (30 x 1) = 30 Ah @ the 1-hour rate(C1)
Therefore, if you have an application that requires a draw of 17 amperes for 3 hours, you would need a 51Ah battery (@ the 3 hour rate)...(17 x 3 = 51). However, this is 100% of the capacity of this 51 Ah battery

Battery Life

The life of Lead Acid batteries is usually limited by several factors：

The battery cycle life for a rechargeable battery is defined as the number of charge/recharge cycles a secondary battery can perform before its capacity falls to 80% of what it originally was (end of Life). This is typically between 500 and 1200 charge – discharge cycles also known as cycle life.

The battery shelf life is the time a battery can be stored inactive before its capacity falls to 80%. The reduction in capacity with time is caused by the depletion of the active materials by undesired reactions within the cell.

Age also affects batteries as the chemistry inside them attacks the lead plates. The healthier the "living Conditions" of the batteries, the longer they will serve you. Lead-Acid batteries like to be kept at a full Charge in a cool place. Only buy recently manufactured batteries. The longer the battery is kept in a store, less time it will serve you! Since lead-acid batteries will not freeze if fully charged, you can store them in the cold during winter to maximize their life.

Batteries can also be subjected to premature death by:

- Over-charging
- Over-discharging
- Short circuiting

Battery Life

- Drawing more current than it was designed to produce
- Subjecting to extreme temperatures
- Subjecting to physical shock or vibrations

Sulphation is a constant threat to batteries that are not fully re-charged. A layer of lead sulphate can form in these cells and inhibit the electro-chemical reaction that allows you to charge/discharge batteries. Many batteries can be saved from the recycling heap if they are Equalized.

Say

What is Depth of Discharge
DOD, short for the Depth of Discharge, is used to describe how deeply the battery is discharged. If we say a battery is 100% fully charged, it means the DOD of this battery is 0%, If we say the battery have delivered 30% of its energy, here 70% energy reserved, we say the DOD of this battery is 30%.

Ask

Does depth of discharge affect cycle life?
Yes! The harder any battery has to work, the sooner it will fail.

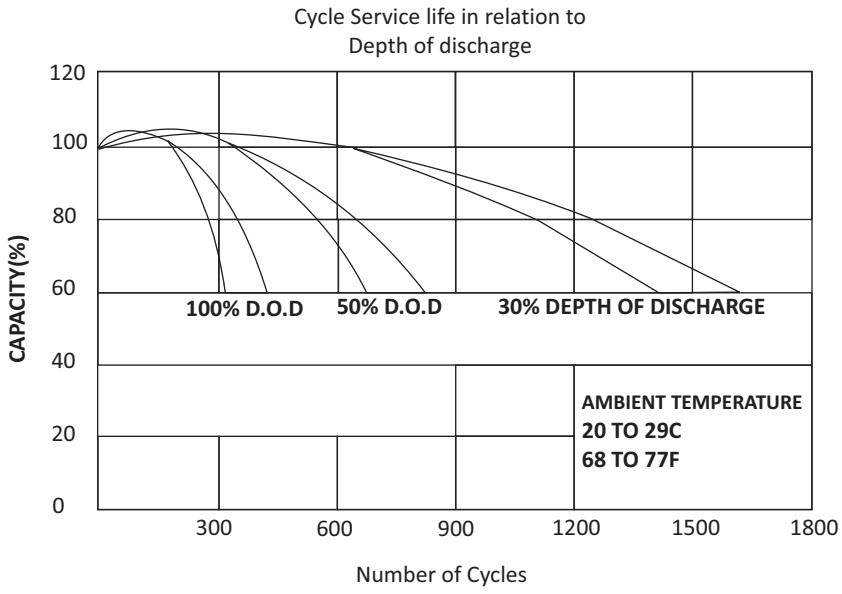


Fig. 2.5.5 Depth of Discharge

This is a typical graph showing number of cycles and its relation to the D.O.D (GEL)
As you can see, the shallower the D.O.D (depth of discharge), the longer the life. This is why it' important to size a battery system to deliver at least twice the average power required, to assure shallow discharges ,therefore prolong the cycle life. Please:

- Avoid ultra-deep discharges.
- Don't leave a battery at a low stage of charge for an extended length of time. Charge a battery as soon as possible after discharged.
- Don't cycle a battery at a low state of charge without regularly recharging fully.
  Ultra-deep discharging is what causes life-shortening plate shedding and accelerated positive grid corrosion which can destroy a battery.

Ask

Why does temperature have such a dramatic effect on batteries?
Temperature is a major factor in battery performance, shelf life, charging and voltage control. At higher temperatures there is dramatically more chemical activity inside a battery than at lower temperatures.

What is Stack Design and Weight?
This is the new technology used to increase the power of the battery by packing more numbers of cell together and reducing their weight by using new innovation.

What is a float charge and how does this work?

A float charger (also called a storage charger, maintenance charger, or smart charger) will charge a battery at a similar rate as a battery self-discharges, thus maintaining a full capacity battery. However, the main difference between a trickle charger and a float charger is that a float charger has circuitry to prevent battery overcharging. A float charger senses when a battery voltage is at the appropriate float level and temporarily ceases charging; it maintains the charge current at zero or a very minimal level until it senses that the battery output voltage has fallen, and then resumes charging. It is important to note that the appropriate float voltage varies significantly with the construction of the battery and the ambient temperature. With the appropriate voltage for the battery type and with proper temperature compensation, a float charger may be kept connected indefinitely without damaging the battery.

Activity

- This is a skill practice activity to understand the difference between Float Charging, Trickle Charging and Boost Charging of a Battery
- Ask the students to assemble together and groups
- Explain to them, what we are going to do in this practical exercise
- Please ensure that since we might get in touch with electrolyte which is an acid, special precaution need to be taken to ensure that no participant gets acid burn
- Ask the students to do this activity separately and gain practice
- Details of the skill activity are given below.

Skill Practice	Time	Resources
Understanding Boost Charging, Trickle Charging and Float Charging in a Battery.	4 hours	Battery, Gloves, Boost and Float Charger, Voltmeter, Ammeter.

Method to do this activity

Refer to figure 2.5.5 which explains the working of a Float Charging.

A. These wires carry the 12/24/48 volt DC output current that goes to the battery.
B. This printed circuit board contains the core of the float charger, which does many functions together. One it will reduce the input AC voltage to a output DC (Direct Current) Voltage which could be at 12/24/48 V. Two, it will continuously monitor the battery's charge status; fully-charged or under-charged. Third, if a battery becomes undercharged, it will automatically turn the charging cycle on.

C. These wires carry the 220 volt AC (house current) into the printed circuit board. The voltage will later be reduced by the circuitry.

E. These LED indicators let the user know the battery's charge or charging status. Some float chargers use 1 indicator to show that there is power going into the PC board. Other chargers us multiple or multi-color indicators to indicate power to the PC board as well as the on / off state of charger going to the battery.

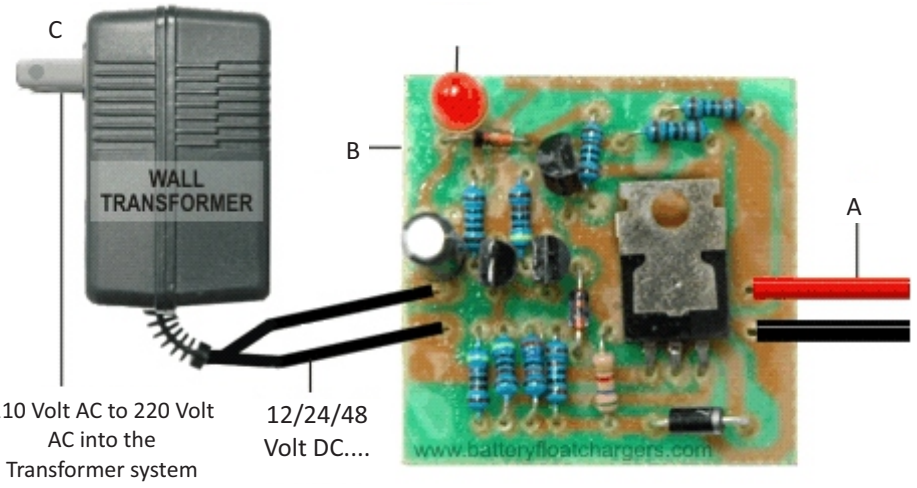


Fig. 2.5.5 Float Charging System

Elaborate

Charging of a Lead Acid battery:
The lead acid battery uses the constant current, constant voltage (CC/CV) charge method for charging. A regulated current raises the terminal voltage until the upper charge voltage limit is reached, at which point the current drops due to saturation. The charge time is 12–16 hours. With higher charge currents and multi-stage charge methods, the charge time can be reduced to 8–10 hours; however, without full topping charge. Lead acid is sluggish and cannot be charged as quickly as other battery systems.

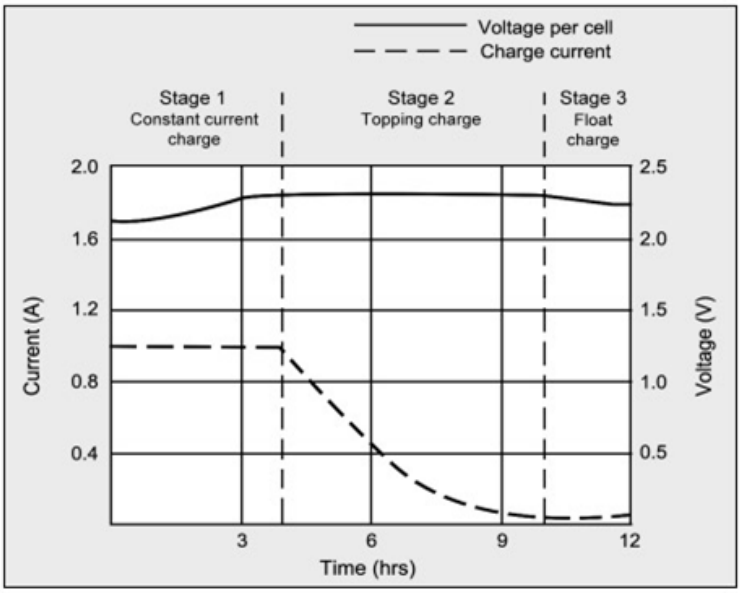
Lead acid batteries should be charged in three stages, which are [1] constant-current charge, [2] topping charge and [3] float charge. The constant-current charge applies the bulk of the charge and takes up roughly half of the required charge time; the topping charge continues at a lower charge current and provides saturation, and the float charge compensates for the loss caused by self-discharge.

During the constant-current charge, the battery charges to about 70 percent in 5–8 hours; the remaining 30 percent is filled with the slower topping charge that lasts another 7–10 hours. The topping charge is essential for the well-being of the battery. If continually deprived, the battery will eventually lose the ability to accept a full charge and the performance will decrease due to sulfation. The float charge in the third stage maintains the battery at full charge. Figure 2.5.6 on the next page illustrates these three stages.
The battery is fully charged when the current drops to a set low level. The float voltage is reduced. Float charge compensates for self-discharge that all batteries exhibit.

The switch from Stage 1 to 2 occurs seamlessly and happens when the battery reaches the set voltage Setting, the voltage threshold. On one hand, the battery wants to be fully charged to get maximum capacity and avoid

sulfation on the negative plate; on the other hand, over-saturation by not switching to float charge causes grid corrosion on the positive plate. This also leads to gassing and water-loss.

Voltage threshold changes with temperature changes the voltage and this makes "dancing on the head of a needle" more difficult. A warmer ambient requires a slightly lower voltage threshold and a colder temperature prefers a higher setting. Chargers exposed to temperature fluctuations include temperature sensors to adjust the charge voltage for optimum charge efficiency.



Stage 1: Voltage rises at constant current to V-peak

Stage 2: Current drops; full charge is reached when current levels off

Stage 3: Voltage is lowered to float charge level

Fig. 2.5.6 Three Stages of a Battery Charging

The charge temperature coefficient of a lead acid cell is –3mV/°C. Establishing 25°C (77°F) as the midpoint, the charge voltage should be reduced by 3mV per cell for every degree above 25°C and increased by 3mV per cell for every degree below 25°C. If this is not possible, it is better to choose a lower voltage for safety reasons. Refer to Figure 2.5.7 below, this compares the advantages and limitations of various peak voltage settings.

	2.3V to 2.35V/Cell	2.40V to 2.45V/Cell
Advantages	Maximum service life; battery stays cool; charge temperature can exceed 30 degree C (86C).	Higher and more consistent capacity reading; less sulfation
Limitations	Slow charge time; capacity readings may be inconsistent and declining with each cycle. Sulfation may occur without equalizing charge	Subject to corrosion and gassing. Needs water refill not suitable for charging at high room temperatures, causing severe overcharge.

Fig. 2.5.7 Effect of Changing Charge Voltage

Once fully charged through saturation, the battery should not dwell at the topping voltage for more than 48 hours and must be reduced to the float voltage level. This is especially critical for sealed systems because they are less tolerant to overcharge than the flooded type. Charging beyond the specified limits turns redundant energy into heat and the battery begins to gas.

The recommended float voltage of most flooded lead acid batteries is 2.25V to 2.27V/cell. Large stationary batteries at 25°C (77°F) typically float at 2.25V/cell. Manufacturers recommend lowering the float charge when the ambient temperature rises above 29°C (85°F).

If your charger stays on topping charge and does not drop below 2.30V/cell, remove the charge after 48 hours of charging. Recharge every 6 months while in storage; AGM every 6–12 months.

These described voltage settings apply to flooded cells and batteries with a pressure relief valve of about 34kPa (5psi). Cylindrical sealed lead acid, requires higher voltage settings and the limits should be set to manufacturer's specifications. Failing to apply the recommended voltage will cause a gradual decrease in capacity due to sulfation. This allows some recombination of the gases generated during charge.

Aging batteries pose a challenge when setting the float charge voltage because each cell has its own unique condition. Connected in a string, all cells receive the same charge current and controlling individual cell voltages as each reaches full capacity is almost impossible. Weak cells may go into overcharge while strong cells remain in a starved state. A float current that is too high for the faded cell might sulfate the strong neighbor due to undercharge. Cell-balancing devices are available which compensate for the differences in voltages caused by cell imbalance.

Ripple voltage also causes a problem with large stationary batteries. A voltage peak constitutes an overcharge, causing hydrogen evolution, while the valley induces a brief discharge that creates a starved state resulting in electrolyte depletion. Manufacturers limit the ripple on the charge voltage to 5 percent.

Lead acid batteries must always be stored in a charged state. A topping charge should be applied every 6 months to prevent the voltage from dropping below 2.05V/cell and causing the battery to sulfate. With AGM, these requirements can be relaxed.

Measuring the open circuit voltage (OCV) while in storage provides a reliable indication as to the state-of-charge of the battery. A cell voltage of 2.10V at room temperature reveals a charge of about 90 percent. Such a battery is in good condition and needs only a brief full charge prior to use.

Observe the storage temperature when measuring the open circuit voltage. A cool battery lowers the voltage slightly and a warm one increases it. Using OCV to estimate state-of-charge works best when the battery has rested for a few hours, because a charge or discharge agitates the battery and distorts the voltage.

Buyers should not accept shipments of new batteries if the OCV at incoming inspection is below 2.10V per cell. A low voltage suggests a partial charge due to long storage or a high self-discharge caused by a micro-short. Battery users have found that a pack arriving at a lower than specified voltage has a higher failure rate than those with higher voltages. Although in-house service can often bring such batteries to full performance, the time and equipment required adds to operational cost.

Activity

- This is a skill practice activity to understand the way to check the State of Charge (SOC) of a battery.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Please ensure that special precautions like use of gloves and glasses are used as the participants might get in touch with the electrolyte which is an acid to prevent acid burn.
- Ask the students to do this activity separately and gain practice.
- Details of the skill activity are given below.

Skill Practice	Time	Resources
To measure battery's State of Charge (SOC).	2 hours	Battery, Gloves, Boost and Float Charger (SMPS), Voltmeter, Ammeter, Ampere-hour meter, Battery Hydrometer.

Method to do this activity

With proper care, quality batteries that are sized correctly for your application will last for years. If abused, an expensive battery bank may last only in months. Taking out too much power without recharging is what kills most batteries. Also, batteries that are low will freeze easily, while a fully-charged battery is good to at least 30 below zero.

Battery capacity is measured in ampere-hours (amp-hours). In rough terms, a 100 amp-hour battery can give out 1 amp for 100 hours, or 100 amps for one hour, or 20 amps for 5 hours. However, see the first item below--you should actually never want to use the entire capacity before recharging.

Meters can be as simple as a voltmeter to measure battery bank voltage and an ammeter to show net gain or loss of power, or as complicated as a digital amp/hour meter (highly recommended).

If possible, never use more than 20% of your battery bank's capacity. If your capacity is 1000 amp-hours, start your back-up generator when the meter shows -200 amp-hours (80% of capacity remaining). Never use more than half your battery capacity without recharging. If you use 75 to 80% of your capacity without recharging, your batteries WILL be damaged, even if they are "deep-cycle" batteries.

To measure battery state-of-charge, there are 3 possible methods.

1. By Voltage: (Refer to fig 2.5.8 and 2.5.9) This method is the least accurate, but requires only a cheap digital voltmeter. Analog meters (with a needle) are generally not accurate enough for this. Wait for 2 hours after any charging or discharging to take your measurement (use your disconnect switches to stop all charging or discharging if necessary). Measure DC voltage across the main positive and negative terminals. As batteries age, this voltage reading will gradually get lower. Measuring voltage across each cell can help diagnose failed cells. Divide the 12 volt reading from this chart by 2 for 6 volt batteries, and by 6 for individual 2 volt cells to figure state of charge (or amount of damage) for the cell. Example: An individual cell would show 2.12 volts at 100% charge when new.

2. By Specific Gravity: This is the most accurate method, but the most messy. You do not have to wait 2 hours to take this reading. It will not work with gel cells or NiCads. You'll need a good battery hydrometer--it will look like a foot long glass turkey baster with a glass float and thermometer inside.

a. Wear goggles and rubber gloves! Keep baking soda and water handy in case you spill!
b. Open up one cell on each battery and suck out enough acid to float the float (or measure every cell if you are ambitious enough).
c. write down the reading
d. average all these readings and compare to the chart

Fig. 2.5.8 Multimeter

Fig. 2.5.9 Checking Battery Voltage

3. By Ampere-Hours: This is best method to measure state of charge, both in accuracy and ease of use. This also makes it easy for people not familiar with your system to avoid abusing the batteries.

a. Amp-hour meters keep track of all power moving in or out of your batteries by time. The efficiency of your battery bank is calculated by the meter while the system operates, and is automatically corrected.
b. Amp-hour meters can sense when the batteries reach full charge, and automatically reset themselves to zero (full) when that point is reached.(Refer to Fig 2.5.10 and 2.5.11)

Fig. 2.5.10 AMP-Hour Meter

Fig. 2.5.11 Measuring State of Charge

c. Any positive reading of amp-hours refers to power that was generated but not stored by the batteries because they were full. This power is in effect wasted, but switching systems can be built to divert the extra power.
d. An amp-hour meter measures power running both ways in the main negative power cable through a "shunt". Any circuit or equipment that is on the wrong side of the shunt (the battery side) will not be metered--this will make your reading inaccurate. Connect all load and charging circuits to the side of the shunt away from the battery bank.
e. The shunt must be big enough to handle all power the system can produce, including the inverter. A standard 500-amp shunt is big enough for most systems. A 100-amp shunt can usually be used in a small system.

2.5.6 Characteristics of a Lead Acid Battery

Say

We are going to see the impact of various parameters on the output voltage and the time of discharge.

1. Temperature Dependence: The rate of the reaction in the cell will be temperature dependent according to theories of kinetics. The internal resistance also varies with temperature; low temperatures give higher internal resistance. At very low temperatures the electrolyte may freeze giving a lower voltage as ion movement is impeded. At very high temperatures the chemicals may decompose, or there may be enough energy available to activate unwanted, reversible reactions, reducing the capacity. The rate of decrease of voltage with increasing discharge will also be higher at lower temperatures, as will the capacity. This is illustrated in fig 2.5.11.

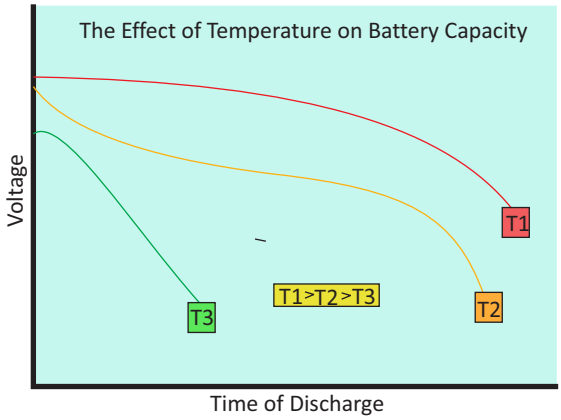


Fig. 2.5.12 Effect of Temperature on Battery Capacity

2. Charge Discharge Cycle: There are many aspects of the cycle that need consideration, such as:
    - Voltage necessary to charge
    - Time necessary to charge
    - Availability of charging source
    - Potential safety hazards during charge/discharge

3. Performance Curve at different Rate of Discharge: As the current drawn increases battery capacity reduces refer fig 2.5.11 of the participant's handbook. As shown if the current is drawn at a rate where battery gets drained out in 1 hr vs 10 hrs the performance of the battery will be drastically different.

2.5.7 Site Hygiene for a Battery Bank

Do

- Based on the knowledge gained by the participants till now, make them speak up few site hygiene conditions for a battery bank.

Say

- Complete and explain the other site hygiene conditions which participants have missed out.

Activity

- This is a skill practice activity to understand the various site hygiene activities are performed on a battery Bank.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Please ensure that special precautions like use of gloves and glasses are used as the participants might get in touch with the electrolyte which is an acid to prevent acid burn.
- Ask the students to do this activity separately them self and gain practice.
- Details of the skill activity are given below.

Skill Practice	Time	Resources
To understand various site Hygiene conditions for a battery bank.	4 hours	Batteries, Gloves, Voltmeter, spanners, Cable and Lugs, Jelly,

Method to do this activity

With proper care and by maintaining site Hygiene conditions the performance and age of the battery can be enhanced many times. In order to do so a proper understanding of these site hygiene conditions is needed by the participant. In this activity all the site hygiene conditions discussed in the unit will be demonstrated to the participants refer page 51-54 of the participant handbook. Participants are suggested to perform/practice on their own so that when on field these technicians should be able to manage the site.

Few of the activities are provide below:

1. Cleaning of the battery Bank(Refer to Figure 2.5.13): Clean the battery tops with rags dipped in a baking soda and water solution. Do not let this cleaning solution get into the batteries-be careful of the vent holes in the caps on each cell, as cleaning solution can enter the battery here.
    a. Re- torque the terminal bolts.
    b. Crimping of the lugs on the wires.
    c. Understand the procedure of dismantling of the battery from a battery Bank.
    d. Understand the procedure of apply jelly on the terminal posts.
2. Few other activities which need to be performed on day to day basis are given below. Its important to practice doing these activities.

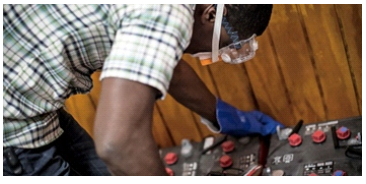


Fig. 2.5.13 Cleaning of Batteries

e. Procedure to identify the plates polarity and stick the stickers in the battery providing date of installation, cell number and polarity labels.
f. Check for corrosion on all the battery terminals (Refer to Figure 2.5.14): If any terminals are encrusted in green "stuff" you should:
    - Make sure that your main power switch is off. If you don't have a main switch, turn off the inverter, all load circuits, and all charging circuits.
    - Carefully disconnect wires from the dirty terminal and clean off the gunk with a wire brush. Don't breath in the dust! Wear a mask if necessary.
    - Apply anti-corrosion paste to the terminal (available at any hardware store in the electrical department).
    - Reconnect the wires.

Fig. 2.5.14 Corrosion on the Battery Terminals

2.5.8: Selecting Capacity of a Battery Bank

Say

1. Capacity of a battery bank depends on the power load of the equipment deployed at a tower site. Some other points on which the selection of a Battery capacity depends are:
    - Discharge current
    - Back-up time required
    - Operating voltage window
    - Temperature
2. Different correction factors used for capacity selection are refer unit 2.5.8, page 55 of the participant handbook:
    - 'k' factor – To consider battery capacity available at particular discharge rate for a particular end cell voltage (ECV)
    - Temperature correction factor – Battery capacity derates with lowering of temp
    - Ageing factor – 1.25 as per IEEE standard 485
    - Design margin – 1.1 to take care of design uncertainties
    - Max %DOD permissible during normal site operation (so that spare capacity is available in case DG fails to start)

Explain

- Explain various correction factors as mentioned above in details, used while selecting the battery capacity.
- Explain the process of calculating the required tower power with an example.

Activity

- This is a skill practice activity to understand the way to calculate the capacity of a battery bank.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to do these calculations themselves so that they are well versed with the procedure to calculate this.
- Details of the skill activity are given below.

Skill Practice	Time	Resources
To understand the method, to calculate the capacity of a battery bank.	2 hours	Projector, Board, Marker, Duster

Method to do this activity

Total Energy Consumption Calculation

Descriptioon	Calculations Steps	Result (units)
Total AC Consumption	SUM 1 (Wh/d)	Wh/day
Total DC Consumption	SUM 2 (Wh/d)	Wh/day
Total Consumption Watt-hours per 24-Hr Day	SUM 1+SUM 2= SUM 3 (Wh/d)	Wh/day
Battery Bank Voltage	Common Voltages: 12V,24V or 48V (V)	V
Total consumption Amp-hours per-24-Hr Day	SUM 3/Battery bank Voltage	Ah

Fig. 2.5.15 Energy Consumption Calculation

Formula for calculating Capacity in AH

Capacity in AH = Load current * K factor for backup hours required * Ageing Factor * Design Margin * temperature correction factor (if ambient temp is lower is lower to 27C)/Normal % DOD permissible

Symbol	Parameter	Range	Comments
TC	Temperature Compensation	Flooded Lead Acid	See Temperature Correction Table
DA	Days of Autonomy	2 – 10*	System Dependent *
DM	Design Margin	1 – 1.25 **	System Dependent
DOD	Depth of Discharge	0.2 – 0.8 ***	Shallow – Deep DOD

Fig. 2.5.16 Battery Adjustment Factors

(°F)	(°C)	Flooded (FLA)	AGM	GEL
70	25.0	1.00	1.00	1.00
50	10.0	1.19	1.08	1.11
32	0	1.39	1.20	1.25
14	-10	1.70	1.35	1.42

Fig. 2.5.17 Temperature Correction Factor

- Refer unit 2.5.8 of the participant handbook and Refer to Figure 2.5.15,2.5.16 and 2.5.17.
- Explain the example of the battery capacity selection in front of all participants.
- Ensure that they understand the way this calculation is done.
- Ask if they have any doubts.

Excercise

- Discuss the questions asked in the participant handbook.

UNIT 2.6: A SMPS Power Plant

Unit Objectives

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

1. Get an understanding of a SMPS power plant.
2. Know the features of a power plant.
3. Identify the components of SMPS power plant.
4. Maintain the site hygiene for a power plant.

2.6.1: Features of a Power Plant

Say

- The definition of a power plant.
- All about a power plant.
- Explain In detail about the Rectifier technology used in SMPS power plant.
- Why power plants in telecom are called as SMPS plants.

2.6.2: Components of a Power Plant

Explain

- The block diagram of a SMPS power plant.
- The battery current limiting circuitry which controls the current supplied to the battery.

Activity

- This is a skill practice activity to know about the components of a power plant and understand the way they operate thus providing a stable DC Power.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to do these calculations themselves so that they are well versed with the procedure to calculate this.
- Details of the skill activity are given below.

Skill Practice	Time	Resources
To know about the components of a power plant and understand the way they operate to provide a stable DC power.	4 hours	SMPS Power Plant,

Method to do this activity

1. Take the participants in front of a SMPS power plant. Refer unit 2.6 of the participant handbook.
2. Open the cover of the power plant so that all components of the plant are visible to participants.
3. Explain all the components in detail so that everyone gets the concept of working of this plant.
4. Describe the technical specifications of each component.
5. Elaborate on the site hygiene conditions which need to be followed. Demonstrate them if possible.

2.6.3: Specification of a Power Plant

Elaborate

- The input and output specifications of a power plant.

Ask

- Incase participants have a doubts which they must ask.

2.6.4: Site Hygiene for a Power Plant

Do

- Discuss all site hygiene points with the participants.

Explain

- All the points discussed in this unit, so that participants get the full concept of these hygiene points.

Excercise

- Discuss the questions asked in the participant guide.

2.7: Air Conditioning System

Unit Objectives

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

1. Understand the need of AC at a tower site.
2. Demonstrate a good knowledge of different types of AC systems.
3. Identify how to provide perfect environment protection at a site.
4. Maintain the site hygiene for air conditioner unit.

2.7.1: Types of Air Cooling System

Do

- Explain different types of air conditioning systems used in industry.
- Talk about the most used systems in the telecom towers.

Explain

The most used system in telecom towers are:

1. Window Air conditioner (Refer to Figure 2.7.1)

This type is the most commonly used system for shelters. In this air conditioner, a single box houses all the components, namely the condenser, evaporator, compressor, cooling coil, and expansion valve. A window air conditioner unit is fitted in a window sill or a slot in the room's wall that is specially made for it. This type is also referred to as a “unitary” air conditioning system. It blows out cooled air on one end (the one inside the room) and eiects heat on the other (the external end).

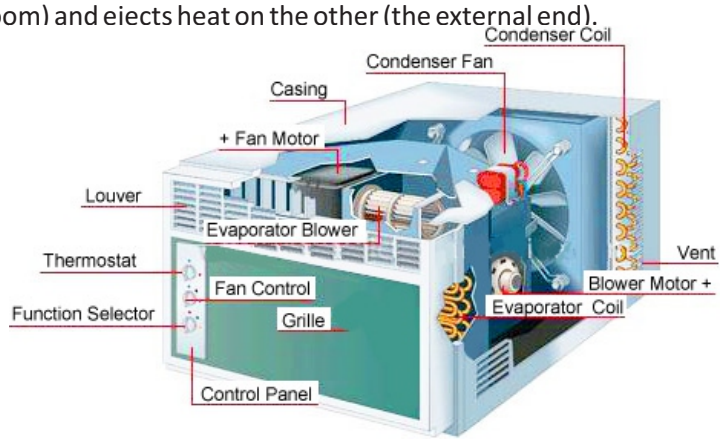


Fig. 2.7.1 Window Air-Conditioning Unit

2. Split or ductless air conditioner (Refer to Figure 2.7.2)
This system is called a “split” system because it is made up of two units: one indoor and one outdoor. The former houses the evaporator and cooling fan. The latter, meanwhile, houses the compressor, expansion valve, and condenser. Split air conditioning systems provide the added convenience of not having to make a slot in the room wall. Also, modern split air conditioners do not take as much space as window units.

Fig. 2.7.2 Split Air-Condioning Unit

2.7.2: Site Hygiene for a Air Conditionering Unit

Do

- Tell all participants to assemble in a group

Discribe

- All the points for maintaining the site hygiene at an AC unit

Activity

- This is a skill practice activity to demonstrate an Air Condition Unit. Show the components of an AC. Explain the site hygiene condition and how to maintain these conditions.
- Ask the students to assemble together and form groups
- Explain to them what we are going to do in this practical exercise
- Ask the students to clarify all the points during this interaction
- Details of the skill activity are given below.

Skill Practice	Time	Resources
To identify the components of an Air Conditioner. Understand the functioning of each component. Explain the site hygiene condition and how to maintain these conditions.	4 hours	Air Conditioner Unit, Screw Driver set.

Method to do this activity

- Open an Air Conditioner unit in front of the group.
- Explain them about each component as visible in the Air Conditioner unit.
- Discuss the site hygiene conditions and the process to implement these conditions.

2.8: Fire Safety

Unit Objectives

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

1. Understand the reasons of fire hazards.
2. Take timely action to control the fire.
3. See how extension of alarms help in fire safety.
4. Discuss about the sensors used for fire safety.

2.8.1: Basics of Fire Safety

Basics of Fire Safety

To minimize and mitigate related risks, usually the companies have taken up various safety related initiatives including safety training for all employees; mock fire drills (day / night) every six months and percolation of safety guidelines and knowledge management on health and safety through mailers and videos (Do's & Don'ts during emergency, Road Safety, articles related to Health, Safety during Fire, Flood and Earthquake etc.). These are a part of the company's transformation journey based on the four pillars - Excellence on Awareness & Employee Communication, Risk Assessment through Audit Mechanism, Corrective & Preventive Actions ("CAPA"), and Bench Marking & best practice sharing within and outside the companies.

Explain

- Reasons of a Fire Hazard
- According to NPFA (National Fire Protection Association) what are the types of fire and what type of Fire extinguishers are used in these fires.

Activity

- This is a skill practice activity to demonstrate a Fire Prevention Drill. This drill should be performed every year to ensure that the all involved with the telecom tower and site work are aware of the actions they need to take to prevent fire.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all the points during this interaction.
- Details of the skill activity are given below

Skill Practice	Time	Resources
To undergo a fire safety drill and explain the precautions need to be taken while going through a fire incident	2 hours	Fire safety equipment, Sensors

Method to do this activity

Fire drills are critical for ensuring the safety of the staff, that enter your business, building or site. Practicing scheduled fire drills will help ensure individuals have the knowledge to safety escape during a fire with out injuring themselves or others.

Fire drills are conducted by the person that is responsible for the maintenance of the site.

Pre-Fire Drill Procedures
To be conducted by supervisory staff or maintenance personnel. Check the fire alarm system and advise them of the upcoming fire drill. Ensure to supply the monitoring company with the estimated time line to conduct the fire drill.

Initiating the Fire Drill

1. Is there a "Fire Drill" feature on the panel?

Yes – utilize this feature to activate alarms for the purpose of the fire drill.
No – activate the nearest manual pull station.

2. Record the time from the activation of the fire alarm to the evacuation of all staff members.

During the Fire Drill
Supervisory staff is to monitor the evacuation process and note any of the following:

- Are individuals closing the doors upon exiting rooms?
- Are individuals remaining calm and proceeding towards the nearest exit?
- Are individuals assembling at the designated muster point?
- Are fire wardens ensuring the safe evacuation of all individuals?
- Are all individuals being accounted for (if applicable)?
- Are exits guarded to prevent re-entry into the building?
- Any fire needed to be exhausted by use of proper fire extinguishers to be done first.

After the Fire Drill

1. Record the total evacuation time in the evacuation checklist report.
2. Silence the alarms, reset the manual pull station and reset the fire alarm system.
3. Ensure the fire alarm system is back to normal operating condition. All Extinguishers are filled up and are back to operating conditions.
4. Inform individuals that they can re-enter the building.
5. Contact the fire alarm monitoring company and the O&M team to advise that the fire drill is complete.
6. Re-evaluate any concerns that arose during the fire drill and discuss as a group (ex. safety meeting).
7. Keep record of the fire drill and any notes on the evacuation checklist report.

2.8.2: Devices and Sensors

Elaborate

- About various types of fire extinguishers used in a telecom tower refer page 64-64 of participant handbook.
- Explain the procedure to use these fire extinguishers at the time of fire.
- On various types of sensors used at a tower site.
- Talk about the connectivity of the sensors with the NOC
- Site Hygiene conditions for Fire Safety.

2.9: Electricity Board (EB) Supply

Unit Objectives

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

1. Know about the three phase power supply from Electricity Board.
2. Explain how this energy coming from EB is measured.
3. State that how electricity flow through a tower site happens.
4. Maintain the Site Hygiene guidelines for the Electricity Board Supply.

Ask

- The participants as what do they understand with Electricity Board and Electricity Board Supply

Say

- The definition of Electricity Board Supply

Explain

- The concept of three phase supply and how is this metered

2.9.1: Electrical Signal Flow

Elaborate

- The overall electrical signal flow through the tower site and distribution of AC and DC (display fig 2.9.3, page 67 of the participant handbook in front of participant.)

2.9.2: Site Hygiene of Electricity Board Supply

Say

- The main points of Site Hygiene as per unit 2.9.2 of participant's handbook

2.10: Earthing at Site

Unit Objectives

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

1. Discuss why Earthing is important for a site.
2. Demonstrate different Earth pits needed at a site.
3. Identify internal details of the Earth pit.
4. Discuss Internal Grounding Bar and its connections.
5. Discuss External Grounding Bar and its connections.
6. Understand overall Earthing connectivity at a tower site.
7. Understand different types of Earthing.
8. Maintain the Site Hygiene needed for proper Earthing.

2.10.1: Objectives of Earthing at Site

Say

- The reasons of having an Earth at the tower site.

Elaborate

- The above mentioned reasons.
- The reasons of having multiple Earth Pits at a tower site.

2.10.2: Anatomy of the Earth Pit

Elaborate

The construction of the Earth Pit and talk of grounding systems consisting of multiple ground rods, connected, meshed or grid networks, ground plates, and ground loops refer page 69-70 of the participant handbook.

Activity

- This is a skill practice activity to demonstrate construction of an Earthing Pit. This activity will provide complete knowledge of how to construct a proper Earthing at a site. .
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all the points during this interaction.
- Details of the skill activity are given below.

	Time	Resources
To construct a new Earth pit as per required specification of a tower site.	6 hours	Multiple ground rods for connected, meshed or grid networks, ground plates, and ground loops. Megger, Funnel with Wire mesh.

Method to do this activity:
An accurate assessment of the soil resistivity should be made around the tower base to determine among other things, the appropriate depth to drive in the copper earth rods, the number of rods and the need for an earth mat, among other things.

Following procedure is followed to create an earth pit.

1. Excavation on earth for a normal earth pit size is 1.5M X 1.5M X 10M
2. Use 500 mm X 500 mm X 10 mm GI Plate (Plate may be use as big as possible to contact more and more area of earth for low resistance & best result)
3. Make a mixture of wood, coal, powder salt & sand, all in equal part:
   (a) Wood Coal Powder use as good conductor of electricity, anti-corrosive, rust proof for GI plate for long life.
   (b) Salt use as electrolyte to form conductivity between GI plate coal and earth with humidity.
   (c) Sand has used to form porosity to cycle water & humidity around the mixture.
4. Put GI plate (EARTH PLATE) of size 500 mm X 500 mm X 10 mm in the mid of mixture.
5. Use double GI strip size 30 mm X 10 mm to connect GI plate to system earthling.
6. It will be better to use GI Pipe of size 2.5" diameter with a Flange on the top of GI Pipe to cover GI Strip from earth Plate to top flange.
7. Cover top of GI pipe with a T joint to avoid jamming of pipe with dust & mud and also use water time to time through this pipe to bottom of earth plate.
8. Maintain less than one ohm resistance from Earth pit conductor to a distance of 15 meters around the earth pit with another conductor dip on the earth at least 500 mm deep.
9. Check voltage between earth pit conductor to neutral of mains supply 220V AC 50 Hz it should be less than 2.0 volts.

Explain

Why do we need to test the grounding systems?
Over time, corrosive soils with high moisture content, high salt content, and high temperatures can degrade ground rods and their connections. So although the ground system when initially installed, had low earth ground resistance values, the resistance of the grounding system can increase if the ground rods are eaten away. Grounding testers are indispensable troubleshooting tools to help you maintain uptime. With frustrating, intermittent electrical problems, the problem could be related to poor grounding or poor power quality. That is why it is highly recommended that all grounds and ground connections are checked at least annually as a part of your normal preventive maintenance plan. During these periodic checks, if an increase in resistance of more than 20 % is measured, the technician should investigate the source of the problem, and make the correction to lower the resistance, by replacing or adding ground rods to the ground systems.

What is a good ground resistance value?

There is a good deal of confusion as to what constitutes a good ground and what the ground resistance value needs to be. Ideally a ground should be of zero ohms resistance. There is not one standard ground resistance threshold that is recognized by all agencies. However, the NFPA (National Fire Protection Association) and IEEE(Institute of Electrical and Electronics Engineers) have recommended a ground resistance value of 5.0 ohms or less. The NEC(National Electrical Code) has stated to "Make sure that system impedance to ground is less than 25 ohms specified in NEC 250.56. In facilities with sensitive equipment it should be 5.0 ohms or less." The Telecommunications industry has often used 5.0 ohms or less as their value for grounding and bonding. The goal in ground resistance is to achieve the lowest ground resistance value possible that makes sense economically and physically.

Activity

- This is a skill practice activity to demonstrate measurement of earth resistance at any tower site. This activity will provide complete knowledge of how to measure the resistance of earth at a site and keep it under the permissible limits.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all the points during this interaction.
- Details of the skill activity are given below:

Skill Practice	Time	Resources
Measurement of Earth pit resistance and keep it within limits as per required specification of a tower site.	4 hours	Clamp on test meter, Megger, Geo Earth Ground tester like Fluke-1625

Method to do this activity

1. Why Determine the Soil Resistivity?
   Soil Resistivity is most necessary when determining the design of the grounding system for new installations (green field applications) or when additional load/ equipment are getting installed at a site to meet your ground resistance requirements. Ideally, you would find a location with the lowest possible resistance. But as we discussed before, poor soil conditions can be overcome with more elaborate grounding systems.
2. Setup for soil resistivity testing: The soil composition, moisture content, and temperature all impact the soil resistivity. Soil is rarely homogenous and the resistivity of the soil will vary geographically and at different soil depths. Moisture content changes seasonally, varies according to the nature of the sub layers of earth, and the depth of the permanent water table. Since soil and water are generally more stable at deeper strata, it is recommended that the ground rods be placed as deep as possible into the earth, at the water table if possible. Also, ground rods should be installed where there is a stable temperature.
3. Soil resistivity measurements are often corrupted by the existence of ground currents and their harmonics. To prevent this from occurring, the Fluke 1625 uses an Automatic Frequency Control (AFC) System. This automatically selects the testing frequency with the least amount of noise enabling you to get a clear reading.
4. An accurate assessment of the soil resistivity should be made around the tower base using any of the following method as shown in the table.(Refer to Figure 2.10.1)
5. Explain all the four methods of calculating soil resistivity to participants.

There are fours ways of measuring Earth at a site.

Figures below explain the selective method (single Clamp) and Stakeless Method (two Clamps).

	Advantages	Drawbacks
Fall-of-Potential	• Widely accepted • When you see the characteristic curve you know you've got a good measurement.	• You have to disconnect ground • The stakes may not be to drive • There may not be space around the ground electrode to drive the stakes.
Selective Method	• Don't have to disconnect electrode • Widely accepted • When you see the characteristic curve you know you've got a good measurement.	• The stakes may not be easy to drive. • There may not be space around the ground.
Stakeless Method	• Convenience	• Assumes a low-impedance parallel path • Possible to get very low readings by mistakenly measuring on a hard-wired loop.
Two-pole Method	• Convenience	• Impossible to judge the integrity of the "auxiliary electrode." • Can't be sure you are outside the area of influence

Fig. 2.10.1 Methods of Calculating Earth Resistance

Elaborate

Explain all four ways of checking the resistence of the soil.

1. Fall of potential:

   Connect the ground tester as shown in the picture. Press START and read out the RE (resistance) value. This is the actual value of the ground electrode under test. If this ground electrode is in parallel or series with other ground rods, the RE value is the total value of all resistances.(Refer to Figure 2.10.2)

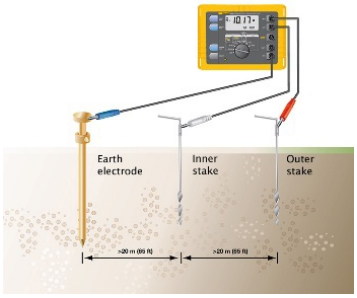


Fig. 2.10.2 The Fall-of-Potential test

2. The selective method is based on the fall of potential test but without the need to disconnect the ground electrode under test. Under this test a current clamp is used to isolate the test current injected in to the electrodes. This application example shows the benefit of the selective test in a typical installation. Firstly the ground spikes are positioned according to the requirements of the system under test. Then individual elements of the system can be measured by placing the currentclamp around the different connections to ground without the need of any power down or disconnection of existing circuits. Multiple electrodes can be tested quickly simply by moving the current clamp to individual electrodes which needs to be tested. The pictures below explain the same (Refer to Figure 2.10.3 and 2.10.4).

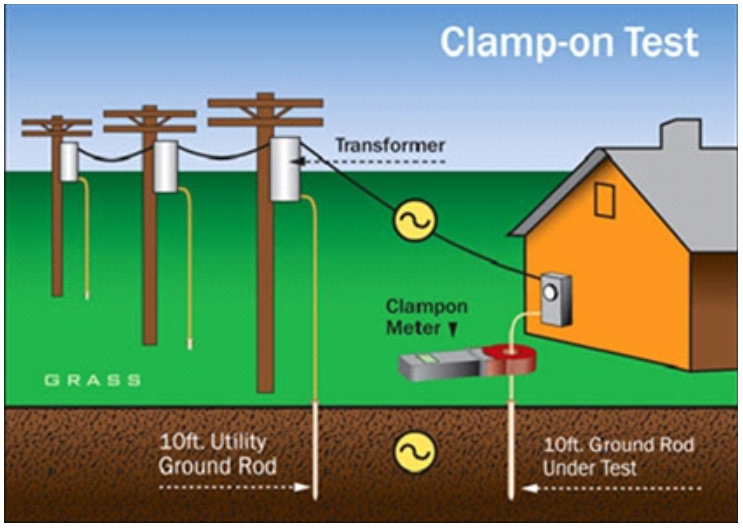


Fig. 2.10.3 Selective Method

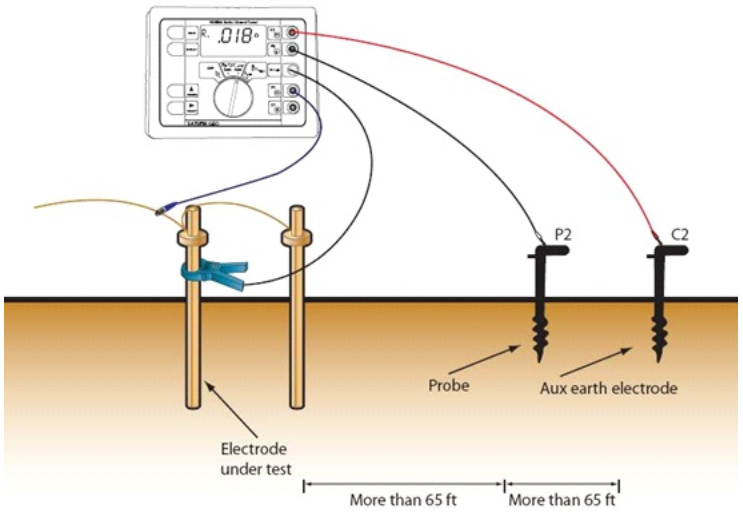


Fig. 2.10.4 Selective Method

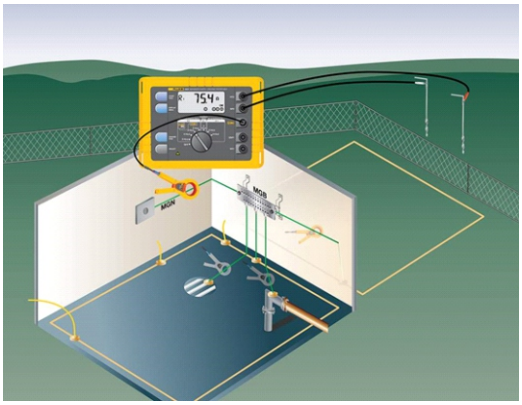


Fig. 2.10.5 Stakeless Method

3. Incase there is no space for fixing Stakes then the most commonly used method is Stakeless method which can be done by using Clamp-on Earth Loop tester. In stakeless method (Refer to Figure 2.10.6) the temporary ground stakes are replaced by two current clamps. The first clamp generates a voltage on the ground conductor; the second clamp measures the current flowing due to the generated voltage. With this test method, two clamps are placed around the earth ground rod or connecting cable and each connected to the tester. As one clamp is generating a field and the other is measuring a field they should be kept apart. Earth ground stakes aren't used at all.
4. The fourth method i.e. two pole method is not used much in telecom systems as the results produced by this test are not much reliable

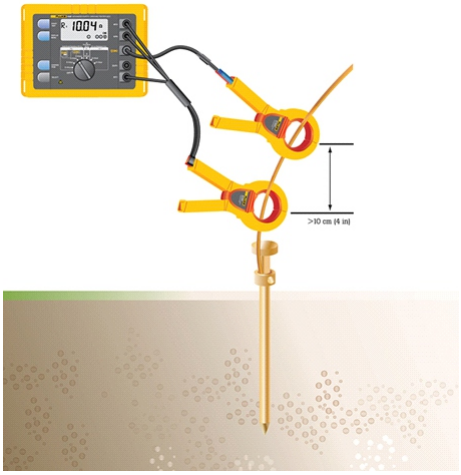


Fig. 2.10.6 Statkeless Method

Ask

2.10.3: Types of Earthing

Say

There are four types of Earthing which can be used at a tower site which are (refer page 73 of particiapant hanbook) :

1. Chamber/ Earth Pit or Spike Electrodes Earth.
2. Pipe/ Bore Earthing.
3. Strip Electrode Earthing.
4. Chemical Earthing.

Elaborate

- Discuss all four types of earthing systems in details with participants. Explain them how each type of earthing is useful and what is the advantage of each vs others

2.10.4: Site Hygiene of Earthing System

Do

Refer page 73 of the participant handbook and explain all the points to the participants.

Ask

If participants have any doubts in the Earthing System and clarify their doubts

2.11: Lightening Arrestors and Aviation Lamp

Unit Objectives

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

1. Understand the concept of Lightening Arrestor.
2. Understand the concept of Aviation Lamp.
3. Discuss the use of Lightening Arrestor and Aviation Lamp.
4. Demonstrate the connectivity details of a Lightening Arrestor.
5. Maintain the Site Hygiene for Lightening Arrestor and Aviation Lamp.

2.11.1: Lightening Arrestor

Ask

- What is the use of Lightening Arrestor?
- How does it protect the telecom site from Lightening.

Elaborate

- Explain in detail the function of Lightening Arrestor using Figure 2.11.1 of the participant handbook. Talk about all the components used in setting up the Lightening Arrestor system

2.11.2: Aviation Lamp

Explain

The use of Aviation Lamp at a Tower site. Clarify doubts of the participant if they have any on this.

2.11.3: Site Hygiene for Lightening Arrestor and Aviation Lamp

Do

Explain the points of Site Hygiene on both Lightening Arrestor and Aviation Lamp to the participants.

2.12: Diesel Generator

Unit Objectives

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

1. Develop good understanding about a diesel generator.
2. Discuss the components of a diesel generator:
3. Identify DG safety devices.
4. Demonstrate installation and commissioning check points.
5. Identify the safety measures to be observed while working on a DG.
6. Maintain the site hygiene at a diesel generator site.

2.12.1: Diesel Generator - An Overview

Say

What is a Diesel Generator?
A diesel generator(Refer to Fig. 2.12.1 and 2.12.2 on next page) is the combination of a diesel engine with an electric generator (often an alternator) to generate electrical energy.

Explain

Draw fig 2.12.2 in participant handbook and explain all the blocks of the Diesel generator.

2.12.2: Components of a Diesel Generator

Activity

- This is a skill practice activity to demonstrate the components of a Diesel Generator. This activity will provide complete knowledge of parts of a diesel generator to the participants
- Ask the students to assemble together and form groups
- Explain to them what we are going to do in this practical exercise
- Ask the students to clarify all the points during this interaction
- Details of the skill activity are given below:

Skill Practice	Time	Resources
Demonstrate all the parts of a Diesel Generator.	2 hours	Tool set, A Diesel Generator which can be dismantled.

Method to do this activity:

Take the participants in front of a Diesel Generator. Open the Diesel Generator. Demonstrate various parts of DG as shown below.

Demonstrate

-Refer page 78-81 of the participant handbook and the figure 2.12.1 and 2.12.2 below. Explain all the parts shown in the guide to participants. Post this practical, they should be able to identify all components of a Diesel Generator.

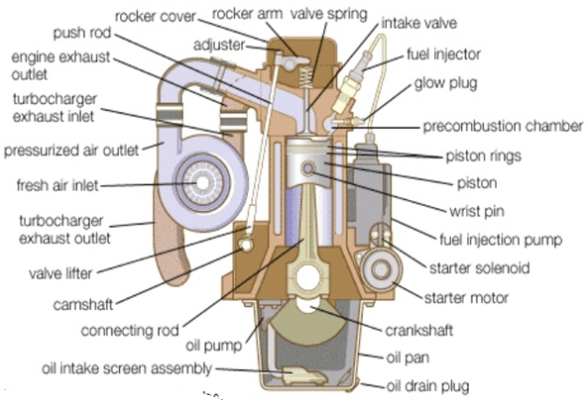


Fig. 2.12..1 Parts of Engine

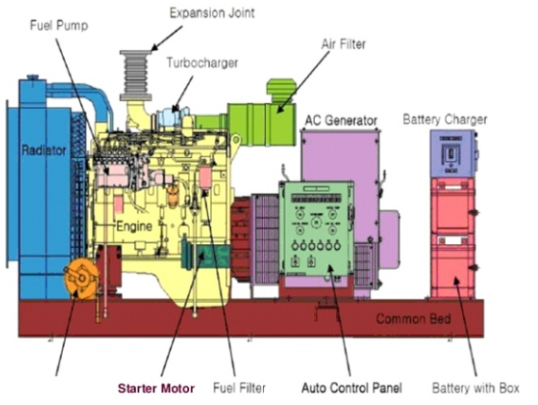


Fig. 2.12.2 Diesel Generator

2.12.3: Engine of a Diesel Generator

Say

- Engine converts the chemical energy to heat energy and mechanical energy

Discuss

- Refer block diagram 2.12.3 of the participants handbook. Discuss the block diagram in detail and explain how the chemical energy gets converted to mechanical energy

Explain

- Four strokes of the diesel generator referring to fig 2.12.4 to 2.1.2.8 of the participant handbook

Activity

- This is a skill practice activity to demonstrate the working of the engine of a Diesel Generator. This activity will provide complete knowledge of four Strokes of the engine of a diesel generator and how these four strokes work in synchronization to generate mechanical energy
- Ask the students to assemble together and form groups
- Explain to them what we are going to do in this practical exercise
- Ask the students to clarify all the points during this interaction
- Details of the skill activity are given below:

Skill Practice	Time	Resources
Demonstrate four strokes of a Diesel Generator and how they work in synchronization to produce Mechanical Energy.	4 hours	Toolset, A Diesel Generator which can be dismantled.

Method to do this activity

1. Take a diesel generator which is used to demonstrate activities to participants
2. Ask the students to form groups around the generator
3. Open the covers of the engine
4. Show the participants all four engine cylinders
5. Rotate the crank shaft and demonstrate the Piston movement
6. Explain them what happens during suction stroke, compression stroke, power stroke and exhaust stroke.
7. Discuss the movement of piston up and down and how the pressure of air in the engine is increased to increase the temperature of air to 560 degree centigrade. Explain how mixing of diesel with Hot air pushes the piston down.
8. Show Intake valve and exhaust valve to the participants.
9. Explain the movement of the emission gases and how they are thrown out of the engine chamber.
10. Demonstrate how all four engines work in synchronization to produce continuous mechanical energy which is used by alternator to produce electrical energy.

Ask

- Ask participants if they have any doubts about the practical demonstrated.

2.12.4: Systems in a Diesel Generator

Say

- Diesel Generator consists of many systems which are defined as:
  1. Air Intake System
  2. Engine Fuel System
  3. Lubrication System
  4. Air Cooling System
  5. Liquid Cooling System
  6. Exhaust System

Let's discuss these systems one by one to get a better understanding about all.

Air Intake System

Say

Air Intake system is the system which is used in a diesel generator to suck fresh air from the atmosphere into the Diesel Generator set. This air is cleaned and dust is removed using a evacuator valve and an Indicator (Ref Fig 2.12.10 to 2.12.13 of participant handbook and figure 2.12.3 below).

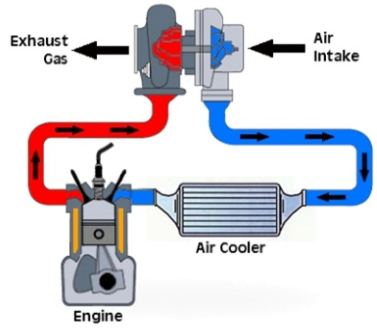


Fig. 2.12.3 Air Intake System

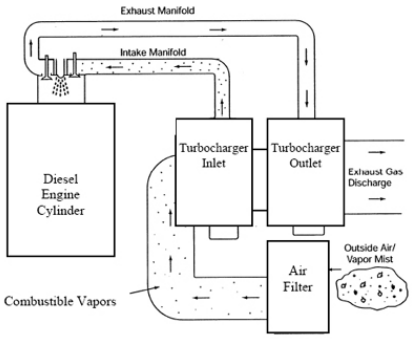


Fig. 2.12.4 Block Diagram of Air Intake system

Activity

- This is a skill practice activity to demonstrate the working of the Air intake system of a diesel engine. This activity will provide complete knowledge of the Air intake system of a diesel Engine
- Ask the students to assemble together and form groups
- Explain to them what we are going to do in this practical exercise
- Ask the students to clarify all the points during this interaction
- Details of the skill activity are given below

Skill Practice	Time	Resources
Demonstrate Air Intake System of a Diesel Engine	2 hours	Tool set, A Diesel Generator which can be dismantled.

Method to do this activity

1. Open the engine of the diesel generator
2. (Refer to Figure 2.12.4 and 2.12.5)explain the Air intake system to the participants.
3. Show the indicator and Dry Air Filter to participants and explain them how to remove the filtered dust from the system.

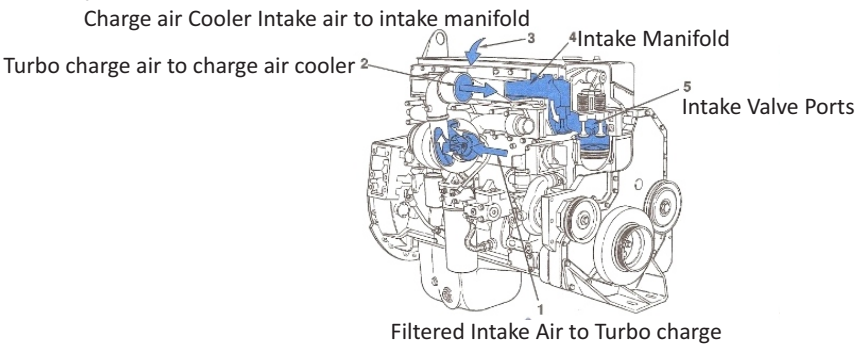


Fig. 2.12.5 Flow Diagram of Air Intake System

Engine Fuel System

Say

Engine fuel system consists of following parts (Refer Fig 2.12.14 of participant handbook)

1. Fuel Tank
2. Feed Pump
3. Fuel Filter
4. Fuel Pump
5. Injector or Nozzle
6. Combustion Chamber
7. Return Pipe Tank

Activity

- This is a skill practice activity to demonstrate the working of Engine Fuel System of a Diesel Engine. This activity will provide complete knowledge of the Engine Fuel System of a diesel Engine.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all the points during this interaction.
- Details of the skill activity are given below:

Skill Practice	Time	Resources
Demonstrate Engine Fuel System of a Diesel Engine	2 hours	Tool set, A Diesel Generator which can be dismantled

Method to do this activity

1. Open the Engine of the Diesel Generator
2. (Refer to Figure 2.12.6 below and page 86 of participant handbook)Explain the Engine Fuel system to the participants
3. Explain the functioning of each component for this system

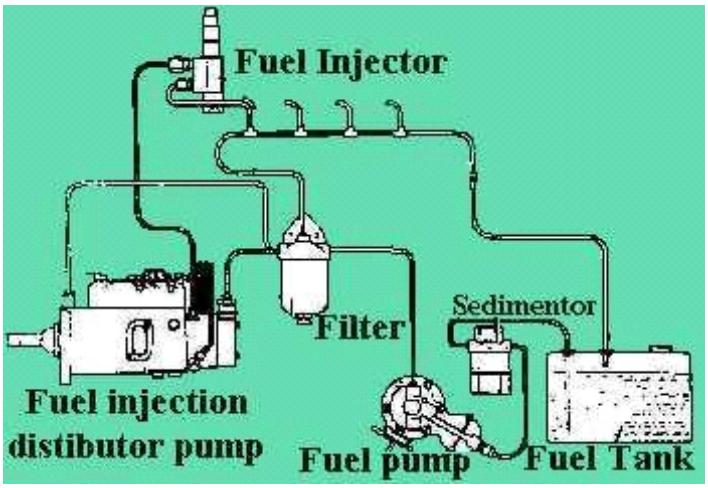


Fig. 2.12.6 Engine Fuel System

Lubrication System

Explain

Refer page 87-89 of the participant handbook. Talk about all three type of mechanisms used in lubrication systems used in a diesel engine.

1. Pressure Lubrication
2. Splash Lubrication
3. Mist Lubrication

Lubrication system consists of the following components:

1. Oil Sump
2. Dipstick
3. Strainer
4. Oil Pump
5. Oil Pressure Gauge
6. Oil Pressure regulating Valve
7. Lube Oil Switch

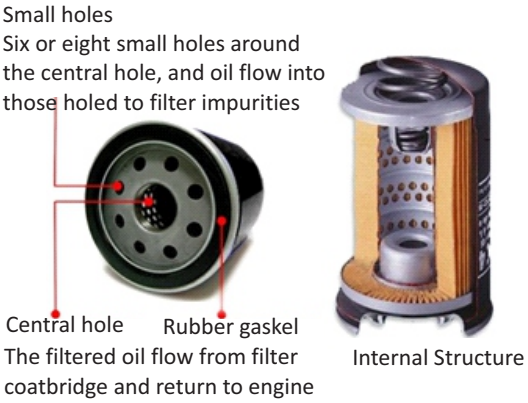


Fig. 2.12.7 Oil Filter and it's construction

Refer to fig 2.12.7 this shows the dissection of an oil filter and the figure below (Refer to 2.12.8) shows the working of the Lubricant system in a Diesel Engine. In the diagram below the light green color represents flow of lubricant oil.

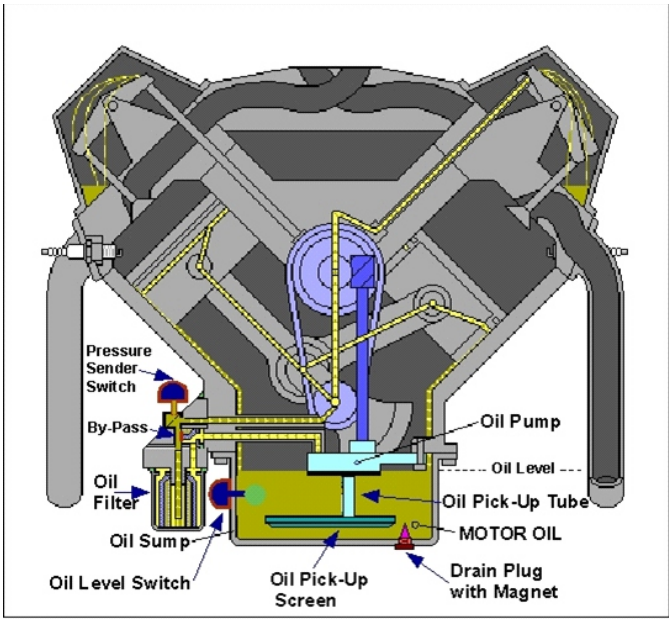


Fig. 2.12.8 Lubricant System of DG

Activity

- This is a skill practice activity to demonstrate the lubrication System of a Diesel Engine. This activity will provide complete knowledge of working of the Lubrication system of a diesel engine
- Ask the students to assemble together and form groups
- Explain to them what we are going to do in this practical exercise
- Ask the students to clarify all the points during this interaction
- Details of the skill activity are given below:

Skill Practice	Time	Resources
Demonstrate Lubrication System of a Diesel Engine and also explain the site hygiene conditions for a lubrica -tion system.	2 hours	Tool set, A Diesel Generator which can be dismantled.

Method to do this activity

1. Open the Engine of the Diesel Generator
2. As per the figure 2.12.8 explain the Lubrication system to the participants.
3. Explain the functioning of each component for the Lubrication system.
4. Explain the Site Hygiene conditions of the lubricating system.

Air Cooling System

Explain

The functioning of the Air Cooling System deployed in the Engine of a Diesel generator. Talk about the components of a Air Cooling System (Refer fig 2.12.18 of the participant handbook)

Activity

- This is a skill practice activity to demonstrate the Air Cooling System of a Diesel Engine. This activity will provide complete knowledge of the Air Cooling System of a Diesel Engine.
- Ask the students to assemble together and form groups
- Explain to them what we are going to do in this practical exercise
- Ask the students to clarify all the points during this interaction
- Details of the skill activity are given below:

Skill Practice	Time	Resources
Demonstrate working of the Air Cooling System of a Diesel Engine and also explain the site hygiene conditions for the Air Cooling system.	2 hours	Tool set, A Diesel Generator which can be dismantled.

Method to do this activity

1. Open the Engine of the Diesel Generator
2. As per the diagram below (Refer to Figure 2.12.9) explain the Air Cooling system to the participants.
3. Explain the functioning of each component of the Air Cooling System.
4. Explain the Site Hygiene conditions which need to be taken care for this system.

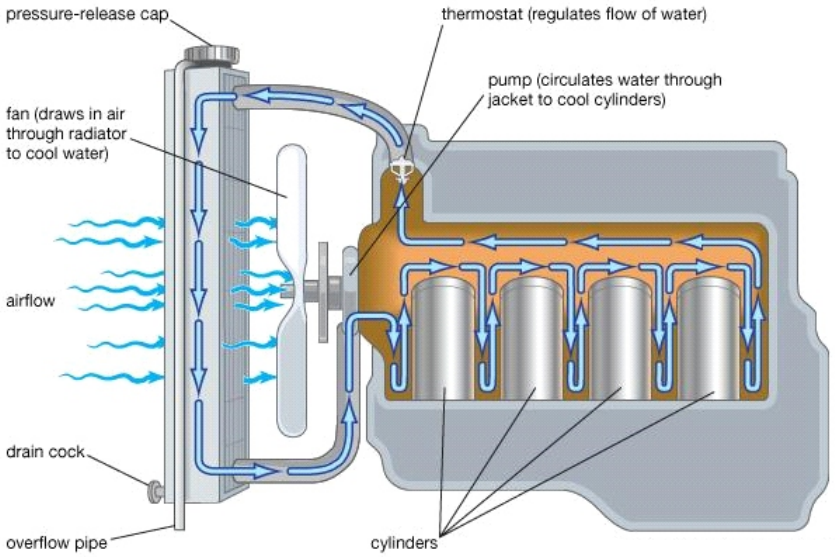


Fig. 2.12.9 Air Cooling System

Water Cooling System

Explain

The functioning of the Water Cooling System deployed in the Engine of a Diesel generator. Talk about the components of the Water cooling system (Refer fig 2.12.19) and the picture below.

Activity

- This is a skill practice activity to demonstrate the Water Cooling System of a Diesel Engine. This activity will provide complete knowledge of the Water Cooling System of a diesel Engine.
- Ask the students to assemble together and form groups
- Explain to them what we are going to do in this practical exercise
- Ask the students to clarify all the points during this interaction
- Details of the skill activity are given below:

Skill Practice	Time	Resources
Demonstrate working of the Water Cooling System of a Diesel Engine and also explain the site hygiene conditions for the Water Cooling system.	2 hours	Tool set, A Diesel Generator which can be dismantled.

1. Open the Engine of the Diesel Generator
2. As per the diagram below(Refer to Figure 2.12.10) explain the Water Cooling system to the participants.
3. Explain the functioning of each component for the Water Cooling system.
4. Explain the Site Hygiene conditions which need to be taken care for this system.

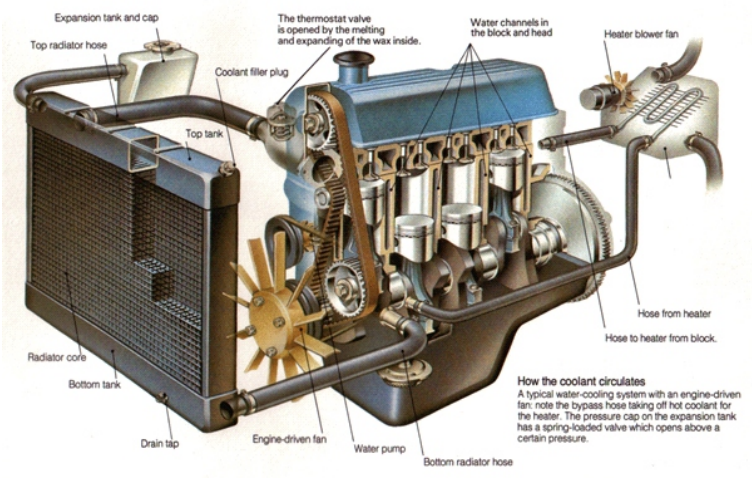


Fig. 2.12.10 Water Cooling System

Exhaust System

Say

- Exhaust system is used to throw out hot smoke generated from the engine after burning of the fuel. This system includes the following:
  1. Exhaust Pipe
  2. Exhaust Silencer
  3. Condensation Trap
  4. Rain Cover

Explain

- The functioning of the Exhaust System deployed in the Engine of a Diesel generator. Talk about the components of the Exhaust system (Refer fig 2.12.20 of the participant handbook) and figure 2.12.11 on next page

Activity

- This is a skill practice activity to demonstrate the Exhaust System of a Diesel Engine. This activity will provide complete knowledge of the Exhaust System of a diesel Engine
- Ask the students to assemble together and form groups
- Explain to them what we are going to do in this practical exercise
- Ask the students to clarify all the points during this interaction
- Details of the skill activity are given below:

Skill Practice	Time	Resources
Demonstrate working of the Exhaust System of a Diesel Engine and also explain the site hygiene conditions for the Water Cooling system.	2 hours	Tool set, A Diesel Generator which can be dismantled.

Method to do this activity:

1. Open the engine of the diesel generator
2. As per the diagram below(Refer to Figure 2.12.11) explain the exhaust system to the participants.
3. Explain the functioning of each component for the exhaust system(refer page 91-92 of the participant handbook).
4. Explain the site hygiene conditions which need to be taken care for this system.

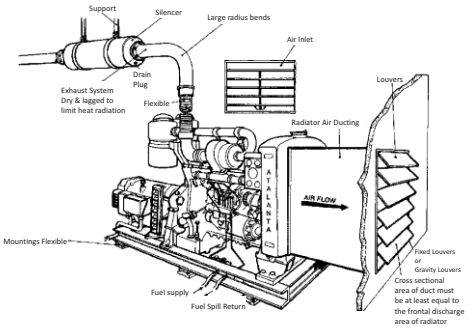


Fig. 2.12.11 Exhaust System

Elaborate

- Refer page 92 of the participant handbook. Explain different types of smokes produced in a diesel generator and the reason for that color of smoke

2.12.5: Alternator of a Diesel Generator

Ask

- Talk to students about their understanding on Alternator

Say

An alternator is a machine that converts mechanical energy to electrical energy. In a diesel generator alternator performs the most important function of producing the electrical energy from the fuel burnt in the engine of the generator. Alternators work on the principle of electromagnetic induction and consist of a stationery armature (stator) and a rotating field rotor.

Elaborate

How Does an alternator Work?

Below figure(Refer to Figure 2.12.12) helps you understanding how an alternator or AC generator works. According to the Faraday's law of electromagnetic induction, whenever a conductor moves in a magnetic field EMF gets induced across the conductor. If the close path is provided to the conductor, induced emf causes current to flow in the circuit.

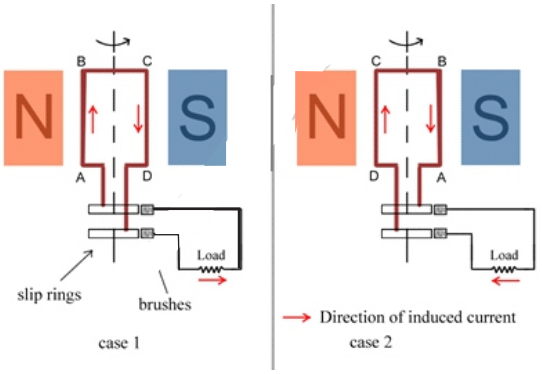


Fig. 2.12.12 Working of Alternator in a AC Generator

Now, see the above figure. Let the conductor coil ABCD is placed in a magnetic field. The direction of magnetic flux will be form N pole to S pole. The coil is connected to slip rings, and the load is connected through brushes resting on the slip rings.
Now, consider the case 1 from above figure. The coil is rotating clockwise, in this case the direction of induced current can be given by Fleming's right hand rule, and it will be along A-B-C-D.

Fleming's right-hand rule (for generators) shows the direction of induced current when a conductor moves in a magnetic field. It can be used to determine the direction of current in a generator's windings.

When a conductor such as a wire attached to a circuit moves through a magnetic field, an electric current is induced in the wire due to Faraday's law of induction. The current in the wire can have two possible directions. Fleming's right-hand rule gives which direction the current flows. The right hand is held with the thumb, first finger and second finger mutually perpendicular to each other (at right angles), Refer to Figure 2.12.13

Fleming's Right Hand Rule

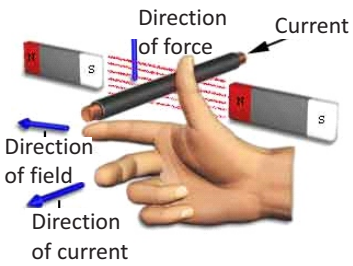


Fig. 2.12.13 Fleming's right hand rule

- The thumb is pointed in the direction of motion of the conductor.
- The first finger is pointed in the direction of the magnetic field. (north to south)
- Then the second finger represents the direction of the induced or generated current (the direction of the induced current will be the direction of conventional current; from positive to negative).

The bolded letters in the directions above give a mnemonic way to remember the order. Another mnemonic for remembering the rule is the initialism "FBI", standing for **F**orce (or otherwise motion), **B** the symbol for the magnetic field, and **I** the symbol for current. The subsequent letters correspond to subsequent fingers, counting from the top. Thumb -> F; First finger -> B; Second finger -> I

As the coil is rotating clockwise, after half of the time period, the position of the coil will be as in second case of above figure. In this case, the direction of the induced current according to Fleming's right hand rule will be along D-C-B-A. It shows that, the direction of the current changes after half of the time period that means we get an alternating current.

Activity

- This is a skill practice activity to demonstrate the Flemings's Right Hand Rule for generation of Electricity and direction of flow of current induced in the generator. This activity will provide complete knowledge of the direction of current generated in a Diesel Generator.
- Ask the students to assemble together and form groups
- Explain to them what we are going to do in this practical exercise
- Ask the students to clarify their all points during this interaction
- Details of the skill activity are given below:

Skill Practice	Time	Resources
Demonstrate Fleming's Right Hand Rule and the direction of current generation in a Diesel Engine.	2 hours	Magnet, Coil and a Galvanometer

Method to do this activity

The Figure above(Refer to Figure 2.12.14) shows the setup needed to do this activity. Follow the following steps:

1. Move the Wire in one direction and see the direction of the current
2. Now move the wire in the opposite direction and see the direction of the current
3. Use Fleming's Right Hand Rule diagram(Refer to Figure 2.12.14) to determine the direction of the flow of current in the circuit(Refer to 2.12.14)

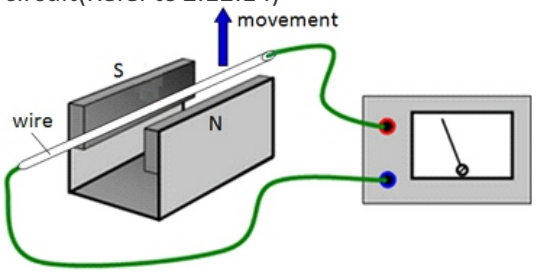


Fig. 2.12.14 Circuit Demonstrating Current Generation

Explain

Faraday Law:

In 1831, Michael Faraday, an English physicist gave one of the most basic laws of electromagnetism called Faraday's law of electromagnetic induction. This law explains the working principle of most of the electrical motors, generators, electrical transformers and inductors. This law shows the relationship between electric circuit and magnetic field. Faraday performed an experiment with a magnet and coil. During this experiment, he found how emf is induced in the coil when flux linked with it changes.

Activity

- This is a skill practice activity to demonstrate the Faraday's law and its relationship with the EMF/voltage generated. This activity will provide complete knowledge of the concept behind generation of Electricity in a diesel generator.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all the points during this interaction.
- Details of the skill activity are given below:

Skill Practice	Time	Resources
Demonstrate Faraday's Law and its relationship with the Voltage generation in a Diesel Engine.	2 hours	Magnet, Coil and a Galvanometer

Method to do this activity

Faraday's Experiment: Relationship between in induced EMF and Flux

This is the basic working principle of electrical generator. Electric generator is used to convert mechanical energy into electrical energy.

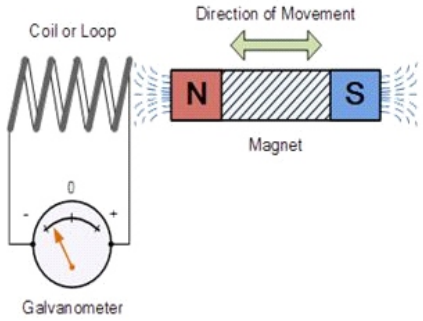


Fig. 2.12.15 Principle of Electrical Generator

In this experiment, Faraday takes a magnet and a coil and connects a galvanometer across the coil. At starting, the magnet is at rest (Refer to Figure 2.12.15), so there is no deflection in the galvanometer i.e needle of galvanometer is at the center or zero position. When the magnet is moved towards the coil, the needle of galvanometer deflects in one direction. When the magnet is held stationary at that position, the needle of galvanometer returns back to zero position.

Now when the magnet is moved away from the coil, there is some deflection in the needle but in opposite direction and again when the magnet becomes stationary, at that point with respect to coil, the needle of the galvanometer returns back to the zero position. Similarly, if magnet is held stationary and the coil is moved away and towards the magnet, the galvanometer shows deflection in similar manner. It is also seen that, the faster the change in the magnetic field, the greater will be the induced emf or voltage in the coil. Table below explains the condition of the voltage at different positions of the magnet.

Position of magnet	Deflection in galvanometer
Magnet at rest	No deflection in galvanometer
Magnet moves towards the coil	Deflection in galvanometer in one direction
Magnet moves away from the coil	Deflection in galvanometer but in opposite direction
Magnet is held stationary at same position (away from the coil)	No deflection in galvanometer

Conclusion: From this experiment, we concluded that whenever there is relative motion between conductor and a magnetic field, the flux linkage with a coil changes and this change in flux induces a voltage across a coil. Michael Faraday formulated two laws on the basis of above experiments. These laws are called Faraday's laws of electromagnetic induction.

Faraday's Laws

Faraday's First Law

Any change in the magnetic field of a coil of wire will cause an emf to be induced in the coil. This emf induced is called induced emf and if the conductor circuit is closed, the current will also circulate through the circuit and this current is called induced current. Method to change magnetic field:

1. By moving a magnet towards or away from the coil
2. By moving the coil into or out of the magnetic field.
3. By changing the area of a coil placed in the magnetic field
4. By rotating the coil relative to the magnet.

Faraday's Second Law(Refer to Figure 2.12.16)

It states that the magnitude of emf induced in the coil is equal to the rate of change of flux that linkages with the coil. The flux linkage of the coil is the product of number of turns in the coil and flux associated with the coil.

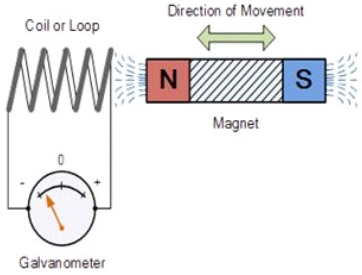


Fig. 2.12.16 Faraday's Law

Faraday Law Formula

Consider a magnet approaching towards a coil.
Here we consider two instants at time T_1 and time T_2.
Flux linkage with the coil at time, $T_1 = N\Phi_1$ Wb(Weber).
Flux linkage with the coil at time, $T_2 = N\Phi_2$ wb.
Change in flux linkage = $N(\Phi_2 - \Phi_1)$.
Let this change in flux linkage be, $\Phi = \Phi_2 - \Phi_1$.
So, the Change in flux linkage = $N\Phi$
Now the rate of change of flux linkage = $N\Phi / t$
Take derivative on right hand side we will get The rate of change of flux linkage = $Nd\Phi/dt$
But according to Faraday's law of electromagnetic induction, the rate of change of flux linkage is equal to induced emf.

$$E = N\frac{d\phi}{dt}$$

Considering **Lenz's law** states that when an emf is generated by a change in magnetic flux according to Faraday's **Law**, the polarity of the induced emf is such, that it produces an current that's magnetic field opposes the change which produces it.)

$$E = -N\frac{d\phi}{dt}$$

Where, flux Φ in Wb = B.A

B = magnetic field strength
A = area of the coil

HOW TO INCREASE EMF INDUCED IN A COIL

- By increasing the number of turns in the coil i.e N- From the formulae derived above it is easily seen that if number of turns of coil is increased, the induced emf also gets increased.
- By increasing magnetic field strength i.e B surrounding the coil- mathematically if magnetic field increases, flux increases and if flux increases emf induced will also get increased. Theoretically, if the coil is passed through a stronger magnetic field, there will be more lines of force for coil to cut and hence there will be more emf induced.
- By increasing the speed of the relative motion between the coil and the magnet - If the relative speed between the coil and magnet is increased from its previous value, the coil will cut the lines of flux at a faster rate, so more induced emf would be produced.

Activity

- This is a skill practice activity to demonstrate the Lenz's law and its relationship with the direction of the current produced in the Generator. This activity will provide complete knowledge of the direction of the current generated by change in flex through movement in a magnetic field in a Diesel Generator.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all the points during this interaction.

Skill Practice	Time	Resources
Demonstrate Lenz's law and its relationship with the direction of the current produced in the Generator. This activity will provide complete knowledge of the direction of the current generated by change in flex through movement in a magnetic field	2 hours	Magnet, Coil and a Galvanometer.

Method to do this activity
For understanding Lenz's law, consider two cases:

When the north pole of the magnet is approaching towards the coil(Refer to 2.12.17), the magnetic flux linked to the coil increases. According to Faraday's law of electromagnetic induction, when there is change in flux, an EMF and hence current is induced in the coil and this current will create its own magnetic field. Now according to Lenz's law, this magnetic field created will oppose its own or we can say opposes the increase in flux through the coil and this is possible only if approaching coil side attains north polarity, as we know similar poles repel each other. Once we know the magnetic polarity of the coil side, we can easily determine the direction of the induced current by applying right hand rule. In this case, the current flows in anticlockwise direction.

CASE-II When a magnet is moving away from the coil

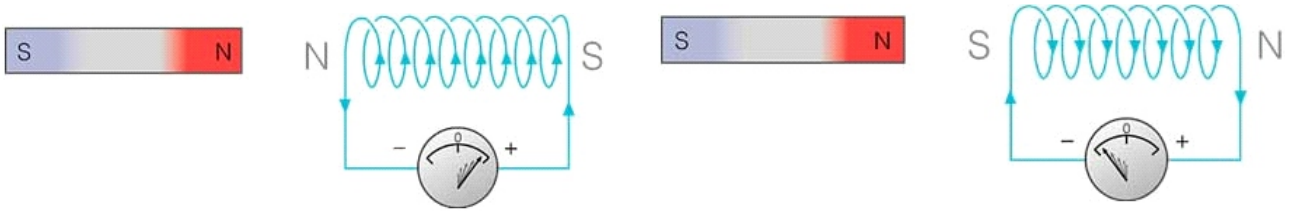


Fig. 2.12.17 Lenz's Law

When the north pole of the magnet is moving away from the coil, the magnetic flux linked to the coil decreases. According to Faraday's law of electromagnetic induction, an EMF and hence current is induced in the coil and this current will create its own magnetic field. Now according to Lenz's law, this magnetic field created will oppose its own or we can say opposes the decrease in flux through the coil and this is possible only if approaching coil side attains south polarity, as we know dissimilar poles attract each other. Once we know the magnetic polarity of the coil side, we can easily determine the direction of the induced current by applying right hand rule. In this case, the current flows in clockwise direction.

NOTE : For finding the directions of magnetic field or current, use right hand thumb rule i.e if the fingers of the right hand are placed around the wire so that the thumb points in the direction of current flow, then the curling of fingers will show the direction of the magnetic field produced by the wire as shown in the figure below. (Refer to Figure 2.12.18)

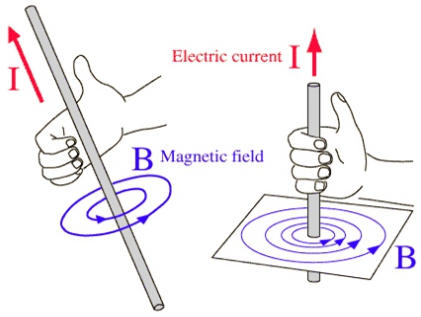


Fig. 2.12.18 Magnetic Field Product by Wire

The Lenz law can be summarized as under:

If the magnetic flux Φ linking a coil increases, the direction of current in the coil will be such that it will oppose the increase in flux and hence the induced current will produce its flux in a direction as shown below (using right hand thumb rule).(Refer to figure 2.5.19)

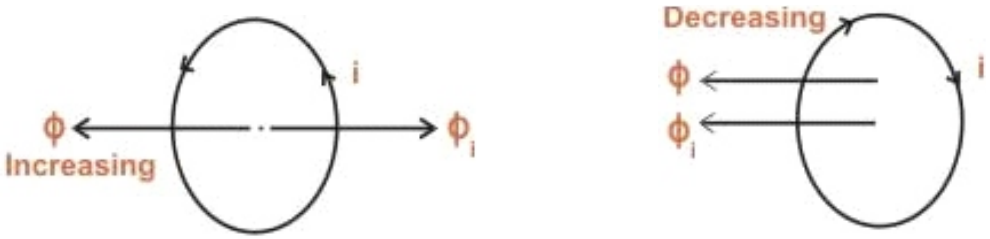


Fig. 2.12.19 Magnetic Flux V/S Current induced

If magnetic flux Φ linking a coil is decreasing, the flux produced by the current in the coil is such, that it will aid the main flux and hence the direction of current is as shown (Refer to Figure 2.12.19).

The working of an Alternator

Diagram shown in the picture (Refer to Figure 2.12.20,2.12.21 and 2.12.22) explains the working of an Alternator.

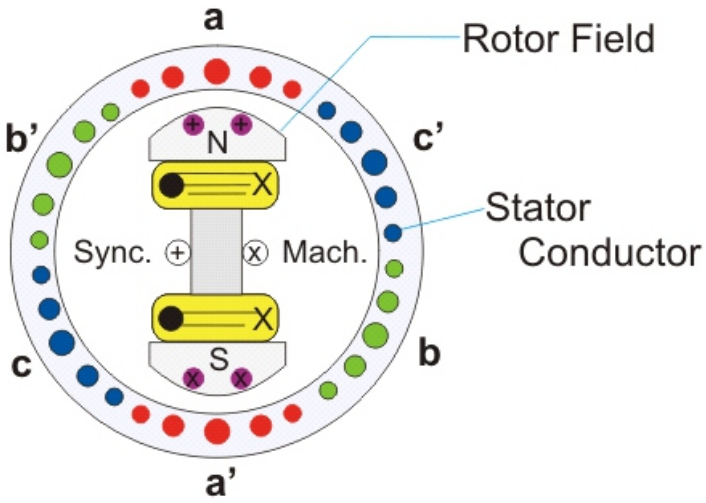


Fig. 2.12.20 Schematic of an Alternator

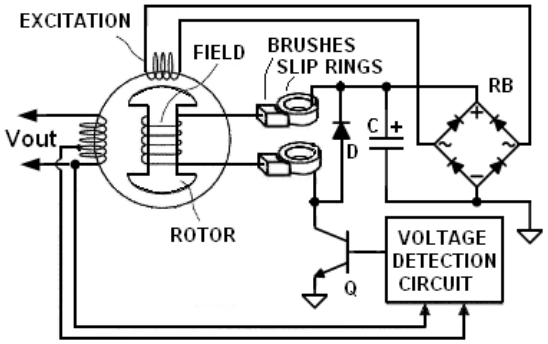


Fig. 2.12.21 Working of an Altenator

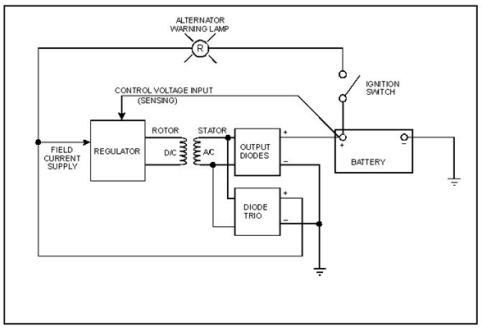


Fig. 2.12.22 Block Diagram of Alternator

A brushless alternator is composed of two alternators built end-to-end on one shaft. Smaller brushless alternators may look like one unit but the two parts are readily identifiable on the large versions. The larger of the two sections is the main alternator and the smaller one is the exciter. The exciter has stationary field coils and a rotating armature (power coils).

The main alternator uses the opposite configuration with a rotating field and stationary armature. A bridge rectifier, called the rotating rectifier assembly, is mounted on a plate attached to the rotor. Neither brushes nor slip rings are used, which reduces the number of wearing parts. The main alternator has a rotating field as described above and a stationary armature (power generation windings). Also in brush less alternator the permanent magnet (or excitation) is used at rotor and the output is taken from stator.
The Alternator consists of the following parts

1. Main Stator
2. Main Rotor
3. Exciter Stator
4. Exciter Rotor
5. Automatic Voltage Regulator (AVR)
6. Rotating Rectifier Assembly (RRA)
7. Terminal Box

Each of the components mentioned above are explained below.

Main Stator

Say

Stator of an alternator is not meant to serve path for magnetic flux. Instead, the stator is used for holding armature winding. The stator core is made up of lamination of steel alloys or magnetic iron.(Refer to Figure 2.12.23)

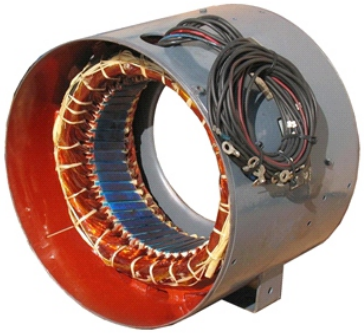


Fig. 2.12.23 Main Stator

Activity

- This is a skill practice activity to demonstrate the Stator of the Alternator of a Diesel Engine. This activity will provide complete knowledge of the Stator of a diesel Engine
- Ask the students to assemble together and form groups
- Explain to them what we are going to do in this practical exercise
- Ask the students to clarify all the points during this interaction
- Details of the skill activity are given below:

Skill Practice	Time	Resources
Demonstrate the Stator of the Alternator and explain the working of the Stator.	2 hours	Tool set, Diesel Generator which can be dismantled, Stator.

- Method to do this activity

1. Open the Alternator of a Diesel Generator .
2. Take out the Stator of the Alternator.
3. Explain the construction of the Stator and the windings over the Core.
4. Explain the Site Hygiene conditions which need to be taken care for this system.

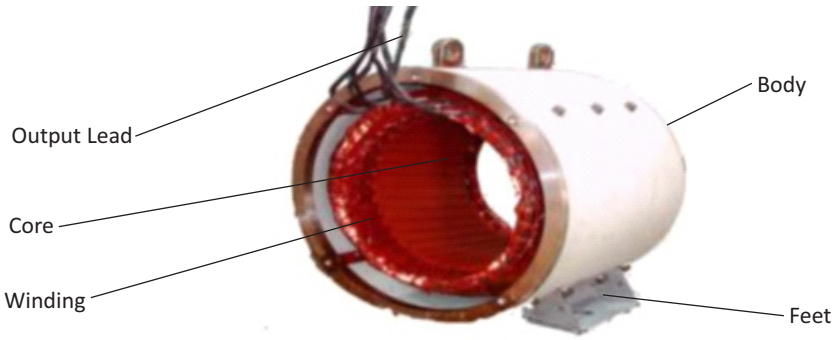


Fig. 2.12.24 Main Stator

5. The Main Stator has the following parts(Refer to Figure 2.12.24)
   a. Core: Consists of laminated stampings having slots.
   b. Winding : Coils are made up of Class H enameled copper conductors, double/Vacuum impregnation with epoxy gel coat on over hangs.
   c. Output Leads: Twelve leads are brought out, sleeved and terminated with suitable crimping sockets.

Main Rotor

Say

Main Rotor moves within the main stator and is made of the winding coils on a core. Coil support blocks are provided for adequate supporting of winding from Centrifugal forces.

Do

Open the main rotor(Refer to Figure 2.12.25) in front of participants

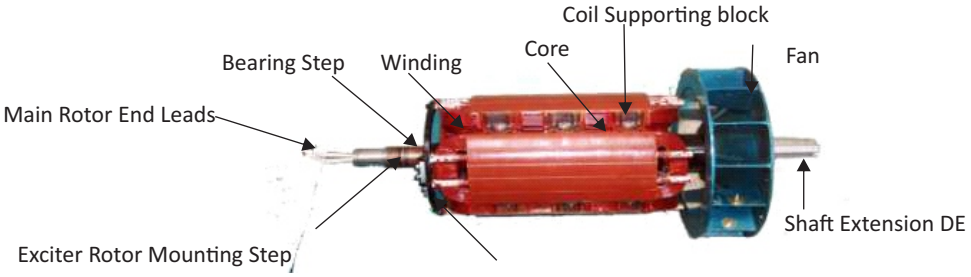


Fig. 2.12.25 Main Rotor

Activity

- This is a skill practice activity to demonstrate the Main Rotor of the Alternator of a Diesel Engine. This activity will provide complete knowledge of the Rotor of a diesel Engine
- Ask the students to assemble together and form groups
- Explain to them what we are going to do in this practical exercise
- Ask the students to clarify all the points during this interaction
- Details of the skill activity are given below:

Skill Practice	Time	Resources
Demonstrate the Rotor of the Alternator and explain the working of the Main Rotor.	2 hours	Tool set, Diesel Generator which can be dismantled, Main Rotor.

Method to do this activity

1. Open the Alternator of a Diesel Generator
2. Take out the Rotor of the Alternator.
3. Explain the construction of the Rotor which includes the following parts
   a. Core : Consists of laminated stampings with salient poles
   b. Winding : Coils are wound using Class H enameled copper conductor
   c. Resin applied during winding and curing followed by epoxy gel coat on overhangs
   d. Coil support blocks are provided for adequate supporting of the winding from high centrifugal forces
4. The end connections are made and routed through the shaft and to be connected to RRA.

Excitation System: Exciter Rotor and Stator

Say

Excitation System is connected to the main Alternator and provide small amount of Electricity to the field coils of Alternator to generate Electricity. For a machine using field coils, which are used in most large generators, the field current must be supplied, otherwise the generator will be useless. Thus it is important to have a reliable supply. Although the output of a generator can be used once it starts up, it is also critical to be able to start the generators reliably. In any case, it is important to be able to control the field since this will maintain the system voltage. A generator produces output voltage proportional to the magnetic field, which is proportional to the excitation current; if there is no excitation current there is zero voltage. A small amount of (electric) power may control a large amount of power. This principle is very useful for voltage control: if the system voltage is low, excitation can be increased;

if the system voltage is high, excitation can be decreased. For large generators, it is usual to have a separate **exciter** dynamo to be operated in conjunction with the main power generator. This is a small permanent-magnet or battery-excited dynamo that produces the field current for the larger generator. The smaller generator can be either a magneto with permanent field magnets or another self-excited generator. This controls the output of the main Alternator.

Advantages of PMG Excitation Support Systems:

1. A PMG with its appropriate regulator can enhance a generator's transient performance because it will provide a constant Ac voltage input to the automatic voltage regulator (AVR) regard less of the generator's terminal voltage.

2. When the load on the generator is nonlinear due to thyrister (SCR) power supplies such as UPS Systems, variable speed drives etc. the load may produce notches on the voltage severe enough to cause misfiring of the power rectifiers in a shunt excited generator's AVR. When this occurs, the generator's terminal voltage will become unstable. If the generator is fitted with a PMG, the input power to the AVR is isolated from these disturbances, and no voltage un-stability will occur.

3. A PMG is constructed with a permanent magnet rotor which has a very strong magnetic field. This eliminates the need for field flashing which is sometimes necessary with shunt type synchronous generators.

4. Strong and very fast voltage build-up is possible in PMG types of Alternators.

Activity

- This is a skill practice activity to demonstrate the Exciter Rotor and Stator of the Alternator of a Diesel Engine. This activity will provide complete knowledge of the Exciter system of a diesel engine.
- Ask the students to assemble together and form groups
- Explain to them what we are going to do in this practical exercise
- Ask the students to clarify all the points during this interaction
- Details of the skill activity are given below:

Skill Practice	Time	Resources
Demonstrate the Exciter Rotor and Stator of the Alternator and explain the working of the Exciter System.	2 hours	Tool set, Diesel Generator which can be dismantled, Exciter Rotor and Stator.

Method to do this activity

1. Open the Alternator of a Diesel Generator .
2. Take out the Exciter system of the Alternator. The positioning of the Exciter system is shown in the figure below(Refer to Figure 2.12.26 and 2.12.27).

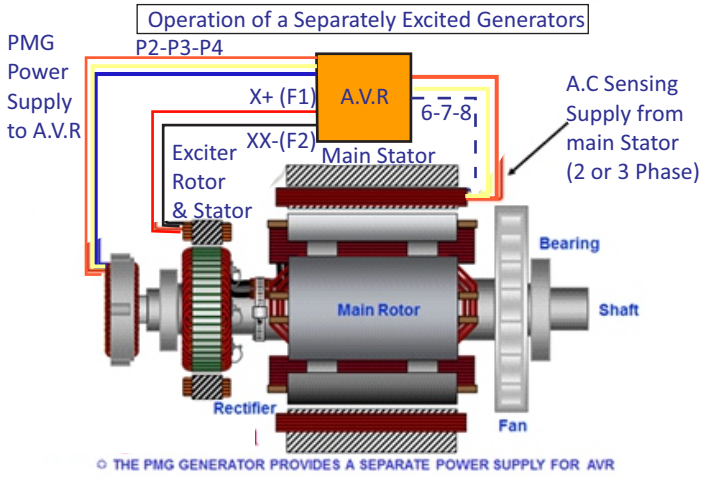


Fig. 2.12.26 Operation of Separately Excited Generators

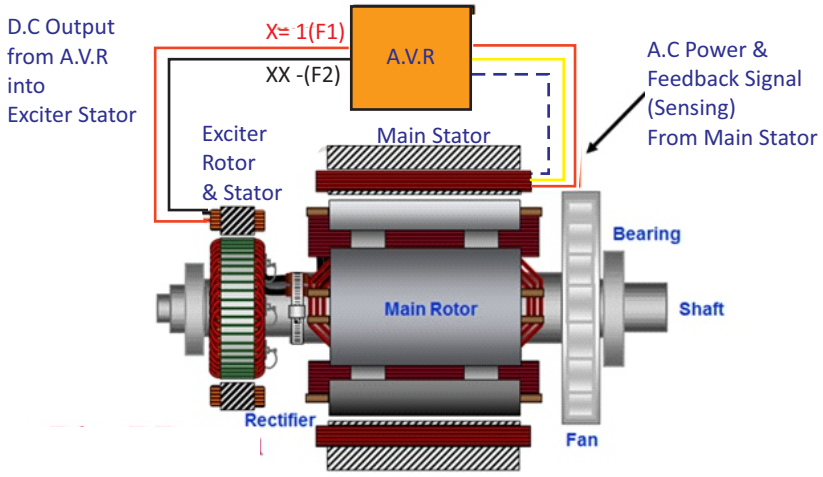


Fig. 2.12.27 Operation of the Self Excited Generator

3. Explain the working of the Exciter System and how it is important for the operation of a DG system(Refer to Figure 2.12.28

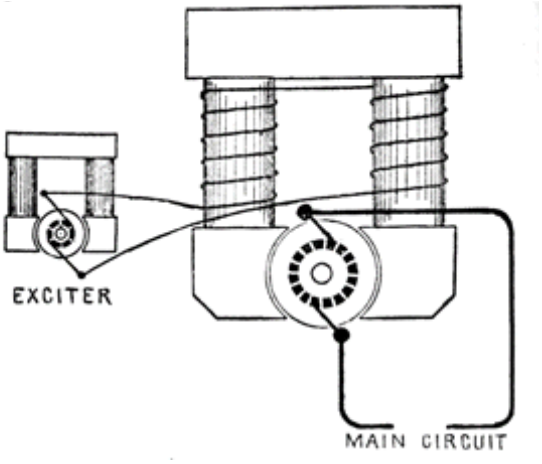


Fig. 2.12.28 Working of Exciter System

4. Explain the construction of the Exciter Rotor and Exciter Stator as shown in the figure below(Refer to Figure 2.12.29):

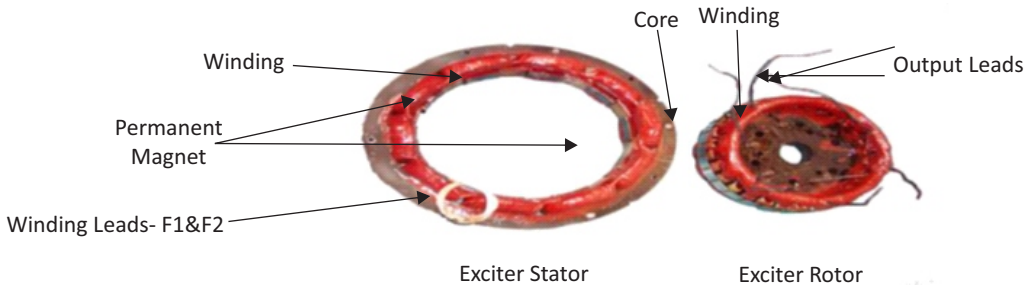


Fig. 2.12.29 Exciter Rotor And Stator

5. Exciter Stator consists of the following:
   Core: Consists of laminated stampings
   Winding: Coils are made using Class H enameled copper conductor. The end connections are made to form alternate N & S poles. Double Impregnation is followed by epoxy gel coat on overhangs.

6. Exciter Rotor consists of the following:
   Core: Consists of thin laminated stamping having slots.
   Winding: Coils are made using Class H enameled copper conductor. Impregnation followed by epoxy gel coat on overhangs.

7. Modern generators with field coils are self-excited, where some of the power output from the rotor is used to power the field coils. The rotor iron retains magnetism when the generator is turned off. The generator is started with no load connected; the initial weak field creates a weak voltage in the stator coils, which in turn increases the field current, until the machine "builds up" to full voltage. Self-excited generators must be started without any external load attached. An external load will continuously drain off the buildup voltage and prevent the generator from reaching its proper operating voltage. If the machine does not have enough residual magnetism to build up to full voltage, usually a provision is made to inject current into the rotor from another source. This may be a battery, a house unit providing direct current, or rectified current from a source of alternating current power. Since this initial current is required for a very short time, it is called "field flashing".

Automatic Voltage Regulator (AVR)

AVR or Automatic voltage regulator's function for generator is to ensure that the voltage generated from power generator running is smooth enough to maintain a stable voltage with in specified limit. It can stabilize the voltage value when suddenly change of load for power supply demand.(Refer to Figure 2.12.30)

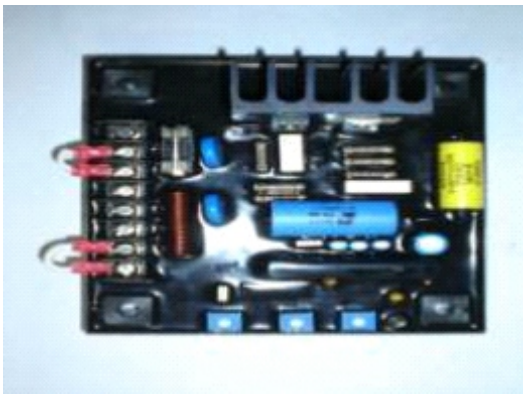


Fig. 2.12.30 Automatic Voltage Regulator (AVR)

A signal proportional to generator terminal voltage obtained from the rectified output of a voltage transformer is compared to a stabilized reference voltage obtained within the regulator.
If any abnormal, different or error signal is detected, it will be amplified and this will control the excitation supply, increase or decrease the input to the main field winding or exciter field. The main purpose is to reduce the error signal to zero or an acceptable value.

Adjustment of the set voltage is obtained either by adjustment of the reference voltage or by adjusting the proportion of machine voltage compared to the reference voltage(Refer to Figure 2.12.31). The stabilizing loop is included to prevent hunting. Below is basic diagram for AVR circuit.

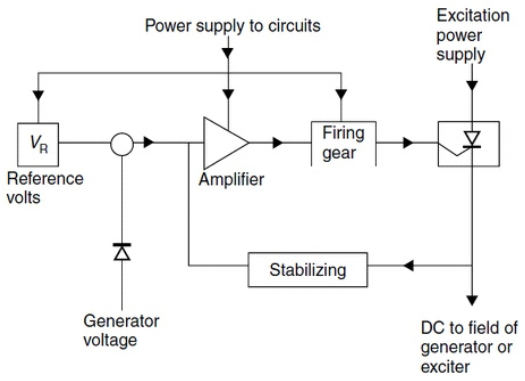


Fig. 2.12.31 Basic Diagram of AVR Circuit

The Permanent Magnet Generator (PMG) with its rotating field and stationary armature supplies high frequency AC power to the voltage regulator. The voltage regulator receives voltage and reactive current feedback provided by potential and current transformers. Comparing these signals to a reference set point in the voltage regulator, the voltage regulator provides a controlled variable DC current to the stationary field of the rotating exciter. With its stationary field and rotating armature, the exciter generates three phase high frequency AC output. This output is rectified by the rotating rectifiers. This DC current is fed via conductors to the center of the rotor shaft and carried by a special lead bar in the hollow shaft area under the bearing journal which is then applied to the main generator field winding. The rotating rectifier is a three phase full wave diode bridge which we will study in next section.

Rotating Rectifier Assembly (RRA)

Rotating Rectifier Assembly(RRA) is a three-phase bridge rectifier mounted on two aluminum heat sinks. Exciter Armature leads are connected to input of RRA as indicated in the diagram below. The output of the rectifier assembly is connected to the main rotor leads. Varistor is provided across the RRA output to suppress any surge voltages as shown in the diagram below.(Refer to Figure 2.12.32)

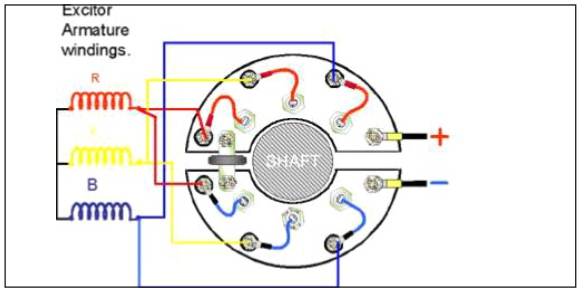


Fig. 2.12.32 Rotating Rectifier Assembly

In this arrangement, the exciter consists of an inverted three phase alternator which has its three phase armature on the rotor and its field on the stator. Its AC armature voltage is rectified in diodes mounted on the rotating shaft and then fed directly into the field (Rotor) of the main synchronous generator.

Activity

- This is a skill practice activity to demonstrate the Automatic Voltage Regulator (AVR) and RRA of an Alternator of a Diesel Engine. This activity will provide complete knowledge of AVR and RRA of a diesel Engine.
- Ask the students to assemble together and form groups
- Explain to them what we are going to do in this practical exercise
- Ask the students to clarify all the points during this interaction
- Details of the skill activity are given below:

Skill Practice	Time	Resources
Demonstrate the Automatic Voltage Regulator (AVR) and Rotating Rectified Assembly of the Alternator and explain their working in an Diesel Generator.	2 hours	Toolset, Diesel Generator which can be dismantled, Automatic Voltage Regulator and Rotating Rectified Assembly.

Method to do this activity

1. Open the Alternator of a diesel generator
2. Open the Exciter system
3. Demonstrate the AVR and RRA to participants
4. Explain the block diagram as shown above
5. Explain how AVR and RRA helps in continuous operation of the a diesel generator.

2.13: Guidelines for First-Aid Faculties

Say

- At a working tower site there are possibilities of encountering an emergency situation where an employee or worker can get hurt accidently. In such a situation it is mandatory to maintain the first aid facilities at site.

Explain

- Refer Fig 2.13.1 of participant handbook and explain the activities in detail.

Ask

- If participants have any questions, answer and clarify the same.

Activity

- This is a skill practice activity to demonstrate the First Aid Activities which can be performed at a Tower site. This activity will provide complete knowledge on how to take care of first aid incase that needs to be given to someone.
- Ask the students to assemble together and form groups
- Explain to them what we are going to do in this practical exercise
- Ask the students to clarify all the points during this interaction
- Details of the skill activity are given below:

Skill Practice	Time	Resources
Demonstrate the First Aid Activity to be given to any person at a tower site.	4 hours	First Aid Specialist team, First Aid Box

Method to do this activity

1. Ask participants about the type of issues which can happen at a site.
2. Explain the precautions which they can take to prevent such happening.
3. Elaborate about the First Aid Box and facilities which are present at a site.
4. Talk about the basic First Aid which can be administered to any person.
5. Tell them about some medicines and Bandages which can be given.
6. Show them how to tie a bandage in case of an emergency.

Summarize

In this chapter students have learnt about

- Tower site and its components.
- Details about these components used at site.
- Hygiene conditions required to be followed at site.
- Do and don't need to be followed.

Key Learning Outcomes

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

1. Adhere to PM (preventive maintenance) plan.
2. Comply with beat plan execution for self.
3. Conduct site PM (preventive maintenance).
4. Keep a check on site up-time.
5. Perform unique site down PM (preventive maintenance).
6. Perform health check on site like checking engine oil, voltage etc.
7. Check premature ageing of Battery Bank, Diesel Generator, Air Conditioner, PIU and SMPS.
8. Monitor outages due to Diesel Generator.
9. Close maximum number of complaints registered by doing Corrective Maintenance.
10. Provide timely resolution to trouble tickets raised.

UNIT 3.1: Guidelines for Maintenance Activities

Unit Objectives

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

- Understand the description of the key words used during the maintenance activity.
- Identify the guidelines which are to be followed while doing the maintenance activity.

Notes for Facilitation

- Invite students to participate. List the expectations on the whiteboard.
- Give the students a brief overview of what all will be covered in the module.

UNIT 3.1.1: Maintenance Activities

Do

- Explain all the definitions and terminology used during maintenance activities to the participants
- Clarify all their doubts and ensure that all participants have understood the key definitions and terminologies
- Discuss and clarify the step by step approach towards maintenance activities
- Explain the procedures involved during these activities

Elaborate

- Refer page 101-102 of the participant guide.
- Project the steps of maintenance on the screen/whiteboard.
- Discussed and explain all the points which are important to provide proper maintenace of the equipments.

UNIT 3.2: Routine Preventive Maintenance

Unit Objectives

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

- Explain the daily maintenance activities.
- Implement the weekly maintenance activities.
- Execute the monthly maintenance activities.
- Timely deliver quarterly maintenance.
- Plan for half yearly and yearly activities in advance.
- Take up maintenance activities as and what they are required.

UNIT 3.2.1: Regular Preventive Maintenance Activities

Say

- Preventive maintenance has to be performed on regular basis for the upkeep of the equipment and structures at the site.

Do

- Put up the list of activities to be done on regular basis in front of the participants.
- Divide these activities to be performed on Daily Basis, Weekly basis, Monthly Basis, Quarterly basis, Half yearly and Annual basis.
- There are some activities which needs to be done as and when they are required.

Explain

- Explain all these activities one by one so that participants understand them clearly.
- Briefly describe the process involved in doing these activities.

UNIT 3.3: Maintenance of Batteries

Unit Objectives

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

- Understand the maintenance activities to be performed on a battery bank.
- Identify the precautions to be taken while handling batteries.
- Differentiate between system monitoring and trouble shooting while maintaining the battery.
- Remove the faulty cell from battery bank by performing discharge test and by using equalization charging
- Demonstrate the procedure of Boost charging of cell.
- Trouble shoot the problem in a battery bank.

UNIT 3.3.1: Installation of Batteries

Say

- Proper installation of the batteries reduces maintenance activities at a later stage.
- It also increases the life of the batteries.

Do

- Put up a list of activities which are performed during the installation of batteries

Explain

- All the listed activities one by one

Activity

- This is a skill practice activity to demonstrate steps involved in installation of a Battery at a tower site. This activity will provide complete knowledge on how to install a Battery and the precautions need to be taken while installing these batteries
- Ask the students to assemble together and form groups
- Explain to them what we are going to do in this practical exercise
- Ask the students to clarify all their points during this interaction
- Details of the skill activity are given below

Skill Practice	Time	Resources
Demonstrate the steps involved in the installation of Battery and the precautions which need to be taken while doing this activity at site. After this activity you should be completely aware of the process of installation of battery.	4 hours	Packed battery and tool kit for installation, Voltmeter, stickers, Markers, Petroleum Jelly, Cloth

Method to do this activity

1. Receive the batteries at site.
2. Check the battery of any damage during transit.
3. If battery is damaged write a note for insurance claim.
4. Explain the precautions which need to be taken while storing these batteries.
5. Demonstrate the process of unpacking the batteries.
6. Show how to do the terminations at the terminals of the batteries.
7. Discuss the precautions to be taken during this process.
8. Explain the post installation process like putting cell numbers, nameplates, date of installation
9. Apply petroleum Jelly on the contractor points
10. Demonstrate this process and explain the utility of applying this Jelly.

UNIT 3.3.2: Preventive Maintenance of Battery Bank

Say

- After proper installation of the batteries, proper preventive maintenance of the batteries has to be done.
- This will increase the life of a battery multiple times.

Do

- Put up a list of activities which are performed for the preventive maintenance of the batteries.

Explain

- The block diagram of a SMPS power plant.
- The Battery current limiting circuitry which controls the current supplied to the battery.

Activity

- This is a skill practice activity to demonstrate various Preventive Maintenance activities to be performed for a Battery at a tower site. This activity will provide complete knowledge on how to do preventive Maintenance of a Battery/ Battery Bank and the precautions need to be taken while doing this.

- Ask the students to assemble together and form groups
- Explain to them what we are going to do in this practical exercise
- Ask the students to clarify all their points during this interaction
- Details of the skill activity are given below

Skill Practice	Time	Resources
Demonstrate the steps involved in doing the preventive maintenance of a Battery/ Battery Bank and the precautions which need to be taken while doing this activity at site. After this activity participant should be completely aware of the process of doing preventive maintenance of battery/ Battery Bank.	6 hours	Battery Bank, PIU, SMPS, and tool kit, Ammeter, Voltmeter, stickers, Markers, Petroleum Jelly, Cloth

Method to do this activity

1. Discuss the list of activities to be performed while doing PM of a battery bank.
2. Demonstrate the process of cleaning the battery on regular basis.
3. Show how to check the leakage in any battery cell.
4. Check all the connections and inter cell connections for tightness.
5. Examine if all Batteries are properly seated on the battery bank stand.
6. Check the earthing connection with the battery bank stand.
7. Show how to check the temperature of individual cell for overheating.
8. Explain how we check the voltage of the individual Cell.
9. Demonstrate how to measure the battery bank charging current.
10. Demonstrate how to check the float charging voltage and current of the battery bank. (voltage should be 2.23 V per cell, current should be 10% of the cell rated capacity)
11. Check the environment condition of the Bank like temp, air flow, no direct sunlight, humidity in the room/ Chiller unit/ area where battery bank is installed. (optimum temperature should be 27 degree C. The temperature compensation factor is -3mv/cell degree rise from the ambient temp of 27°C and vice versa).
12. Any other activity needed depending on the area of deployment.

UNIT 3.3.3: Corrective Maintenance of Battery Bank

Say

- After proper installation of the batteries and proper preventive maintenance of the batteries there will be instances when batteries still don't perform to the expected level then Corrective actions need to be taken.
- In order to perform these corrective actions two different set of activities need to be undertaken.
- These two set of activities are divided as
  - System Monitoring
  - Trouble Shooting

Do

- Put up a list of activities which are performed for doing the corrective maintenance.
- List down what is covered under system Monitoring and what is covered under Trouble Shooting.

Explain

- Discuss in detail all the activities which are covered under System Monitoring and Trouble shooting.

Activity

- This is a skill practice activity to demonstrate various Corrective Maintenance activities to be performed for a Battery at a tower site. This activity will provide complete knowledge on how to do Corrective Maintenance of a Battery/Battery Bank and the precautions need to be taken while doing this.
- Ask the students to assemble together and form groups
- Explain to them what we are going to do in this practical exercise
- Ask the students to clarify all the points during this interaction
- Details of the skill activity are given below.

Skill Practice	Time	Resources
Demonstrate the steps involved in doing the Corrective maintenance of a Battery/ Battery Bank and the precautions which need to be taken while doing this activity at site. After this activity participant should be completely aware of the corrective maintenance activities of battery/ Battery Bank.	4 hours	Battery Bank, PIU, SMPS, and tool kit, DC Voltmeter/ multimeter, stickers, Markers, Petroleum Jelly, Cloth.

Method to do this activity

1. Discuss the list of activities to be performed while doing CM of a Battery Bank.
2. Demonstrate the process of cleaning the battery on regular basis.
3. Show how to check the leakage in any battery cell.
4. Various test to be performed are:
    a. Battery short term discharge test
    b. Equalization charging of Batteries
    c. Boost charging of Batteries (Page 193 of Participant handbook)
    d. Battery Backup test on System Load (Page 194 of Participant handbook)

A. Short Term Discharge Test

Activity

- This is a skill practice activity to demonstrate the Corrective Maintenance activity of Battery Bank called short term discharge test to be performed for a Battery at a tower site. This activity will provide complete knowledge on how to do this corrective Maintenance of a Battery/ Battery Bank and to

remove the damaged cell from the Battery Bank.

- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all the points during this interaction.
- Details of the skill activity are given below.

Skill Practice	Time	Resources
Demonstrate the steps involved in doing the corrective maintenance test involving Short term discharge test of a Battery/ Battery Bank and to use these results in identifying the damaged cells which needs to be changed for proper functioning of a battery bank.	4 hours	Battery Bank, PIU, SMPS, DC Voltmeter/ Multimeter, DC Clamp meter, Standard Toolkit containing Tester, Screwdriver, Plier, Insulation Tape etc., Blank Test format Printouts, Pen/ Pencil

Method to do this activity

1. Go to page 111 of the Participant handbook.
2. Explain all these steps in detail and follow the steps as described there.
3. Fill in the Battery Backup test format sheet with voltage on each cell after 30 min.
4. If the average cell voltage is > 2.0 V, individual cell readings should be within a range of +0.03V, but if the average cell voltage is <2.0 V, individual cell reading should be within a range of +0.1V.
5. If any of the cell voltage falls out of this range cell should be monitored very closely.

B. Equalization Charge of Batteries

Activity

- This is a skill practice activity to demonstrate the Corrective Maintenance activity of Equalization Charging of a battery bank to be performed for a battery at a tower site. This activity will provide complete knowledge on how to do this corrective maintenance activity of Equalization Charging of a Battery/ Battery Bank leading to identification of the damaged cell from the Battery Bank or improving the health of the batteries in a battery bank.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all the points during this interaction.
- Details of the skill activity are given below.

Skill Practice	Time	Resources
Demonstrate the steps involved in doing the corrective maintenance activity of Equalization charging of a Battery/ Battery Bank and to use these results in identifying the damaged cells or improving health of the batteries in a Battery Bank.	4 hours	Battery Bank, PIU, SMPS, DC Voltmeter/ Multimeter, DC Clamp meter, Standard Toolkit containing Tester, Screwdriver, Plier, Insulation Tape etc., Blank Test format Printouts, Pen/ Pencil

Method to do this activity

1. Go to page 112 of the participant handbook.
2. Explain all these steps in detail and follow the steps as described there.
3. Fill in the Battery Backup test format sheet with voltage on each cell.
4. As soon as the cell voltage reaches 1.75 V stop discharge cell and remove the cell from the bank and continue the discharge cell activity till the time all cells reach an end cell voltage (ECV) of 1.75 V and is removed from the bank.
5. Once all the cells are discharged put them back in the bank and charge the battery bank at 0.1 C to 0.2 C rate current for a period of atleast 21 hours.
6. Check the individual cell voltage after this charging. If the variation is more than 0.1V in the cells carry out the discharge test.
7. If during the discharge test cells marked prior to Equalization test are not showing any improvement and voltage is dropping wrt other cells, replace these cells for proper functioning of the battery bank.

C. Boost Charging of a Battery Bank

Explain

- Explain the concept of boost Charging and how this is performed on a battery bank connected to a power plant and a generator.

Activity

- This is a skill practice activity to demonstrate the Corrective Maintenance activity of Boost Charging of a Battery Bank to be performed for a Battery at a tower site. This activity will provide complete knowledge on how to do this corrective maintenance activity of Boost Charging of a Battery/ Battery Bank increasing the charge/Voltage levels of the Battery Bank thus improving the health of the batteries in a battery bank.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all the points during this interaction.
- Details of the skill activity are given below

Skill Practice	Time	Resources
Demonstrate the steps involved in doing the corrective maintenance activity of Boost charging of a Battery/ Battery Bank and to use this to increase the voltage level of each cell improving health of the batteries in a Battery Bank.	4 hours	Battery Bank, PIU, SMPS, DC Voltmeter/ Multimeter, DC Clamp meter, Standard Toolkit containing Tester, Screwdriver, Plier, Insulation Tape etc., Blank Boost Charging format Printouts, Pen/ Pencil

Method to do this activity

1. Go to page 113 of the Participant handbook.
2. Explain all these steps in detail and follow the steps as described there.

3. Fill in the Boost Charging format sheet (page 194) with voltage on each cell and the Charge current before this boost charging exercise.
4. Ensure that the boost charge mode in the power supply (voltage of 2.35 V and charge current of 10% of battery AH capacity) is on for at least 16 Hrs.
5. Measure and record the individual cell voltage and bank charge current during the last hour of boost charging as per the format of Boost Charging sheet.

D. Activity of Battery Backup Test on System Load

Activity

- This is a skill practice activity to demonstrate the corrective maintenance activity of battery backup test on system load to be performed for a battery at a tower site. This activity will provide complete knowledge on how to do this corrective maintenance of a battery/battery bank and to remove the damaged cell from the battery bank.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all their points during this interaction.
- Details of the skill activity are given below.

Skill Practice	Time	Resources
Demonstrate the steps involved in doing the corrective maintenance test involving Backup test on system load of a Battery/ Battery Bank and to use these results in identifying the cells which needs to be changed for proper functioning of a battery bank. This test is performed once a year.	4 hours	Battery Bank, PIU, SMPS, DC Voltmeter/ Multimeter, DC Clamp meter, Standard Toolkit containing Tester, Screwdriver, Plier, Insulation Tape etc., Blank Test format Printouts, Pen/ Pencil

Method to do this activity

1. Go to page 192 of the Participant handbook.
2. Explain all these steps in detail and follow the steps as described there.
3. Fill in the Battery Backup test format sheet with all the readings taken throughout the test.
4. Write the observations and conclusions in the test format sheet.
5. Take action on the conclusions as described in participant handbook.

UNIT 3.4: Maintenance of a Diesel Generator

Unit Objectives

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

- Know about the critical requirements of a DG site.
- Identify the check points that need to be observed while installation of DG.
- Understand the common mistakes that occur during the process of installation and efforts need to be taken to correct these mistakes.
- Learn the importance of proper maintenance.
- Follow the general safety instructions while using a DG.
- Discuss the precautions need to be taken while using an Alternator.
- Perform the corrective maintenance of a DG.

UNIT 3.4.1: Impact of proper installation

Say

- Proper installation of a DG set will ensure that given points are taken care at the time of installation.

Do

- Put up the list of issues to be taken care in front of the participants.

Explain

- Explain all these activities one by one so that participants understand them clearly.
- Briefly describe the process involved in doing these activities.

UNIT 3.4.2: Pre-Requisite for installation of a DG

Do

- Put up the following list of pre-requisites to be taken care before installation of a DG in front of the participants.
  - Selection of location of DG set
  - Ventilation aspects to be considered
  - Foundation for placement of a DG
  - Earthing system
  - Cabling for a DG set
  - Battery for starting the DG

Elaborate

Implementing all the above mentioned points ensure that the Diesel Generator performs without too many problems year after year. Explain all these important conditions in detail so that participants are clear about these factors.

UNIT 3.4.3: Safety Precautions while using a DG

Say

- Refer to 3.4.3 of the participant handbook, points mentioned in this unit need to be followed and understood by all participants.

Explain

- All the safety precautions need to be explained in details with the reasons why they have to be followed.

UNIT 3.4.4: Precautions while using an Alternator

Say

Alternator produces electrical energy from the mechanical energy which gets generated by moving crank shaft of the DG set. This process we have understood in the previous sections. Since the mechanical energy is used to generate the electrical energy precautions need to be taken to ensure that the wastage of this generated energy is avoided and the system is efficient.

Explain

Take few minutes to brush up the concepts used in production of electricity from an alternator. Based on these concepts explain the precautions which need to be taken for efficient running of the Alternator. Refer section 3.4.4 of the participant handbook to talk about the Do's and Don't to be followed for an alternator. Develop the understanding within the participants about various Checkpoints in operation of an alternator. By keeping check on these points you can easily identify the health of an alternator.

Elaborate

Refer Figure 3.4.1 of participants handbook to explain various checkpoints used in an Alternator and proceed to undertake the following activity to create proper understanding of these checkpoints.

Activity

- This is a skill practice activity to demonstrate the Precautions to be taken and the Checkpoints for verifying the proper working of an Alternator for a DG at a tower site. This activity will provide complete knowledge on how to perform various check on a working Alternator to know about the health of its operations. The observations gained from these checks guides the technician to perform right preventive or corrective maintenance on a DG set.
- Ask the students to assemble together and form groups.

- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all the points during this interaction.
- Details of the skill activity are given below

Skill Practice	Time	Resources
Demonstrate the precautions to taken for operation of a DG set and also get a thorough understanding of the check points in an Alternator which provides complete information about the heathy operation of an alternator.	2 hours	Diesel Generator, DC Voltmeter/ Multimeter, Standard Toolkit containing Tester, Screwdriver, Plier, Insulation Tape etc., Pen/ Pencil

Method to do this activity

1. Refer pages 117-122 of the participant handbook.
2. Explain all the points in detail and follow the steps as described there.
3. Describe in details the precautions to be taken during the operations of a DG set.
4. Demonstrate important activities for safe working of an Alternator.
5. Make participants practice to take the readings at Point of observations in an Alternator and how to make inference out of these readings.

UNIT 3.4.5: Steps to Increase Life of a Starter Motor

Say

Starter Motor is used in the Diesel Generator in the following way.

The diesel generator is a combination of diesel engine coupled to an alternator, the engine is a prime mover which in turn rotate the rotor of generator as a result it induces EMF across stator. To do this first, the engine has to be started either manually or by electrically, if the engine is of high capacity then it has to started electrically with the help of electrical starter motor, initial crank or rotation to the engine is given by motor with a high starting torque so as to start the engine. When the engine picks up speed the starter motor is disconnected and pinion is detached from the fly wheel of engine and engine run on its own. The rotor of the generator which is coupled start running as long as the engine is running and produces and supplying electrical power.

Explain

- Refer page 122 of the participant handbook and discuss the steps to be taken to increase the life of a starter motor.

Demonstrate

- Show the position of the starter motor to the participants in the Diesel Generator and demonstrate its working.

Discuss

- Check with the participants if they have understood the same.

UNIT 3.4.6: Maintaining Various Systems of a DG

Air Intake System

Say

Firstly we will discuss maintenance of Air Intake System. Managing the supply of air to the combustion chamber is an important process to ensure consistent and reliable performance of modern diesel generators. Air management encompasses all aspects that affect the quantity, composition, temperature, pressure, bulk motion and cleanliness of the combustion air.

Activity

- This is a skill practice activity to demonstrate the maintenance of the Air Intake system of a Diesel Generator at a tower site. This activity will provide complete knowledge on the activities to be undertaken to perform the maintenance of the Air Intake System.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all their points during this interaction.
- Details of the skill activity are given below.

Skill Practice	Time	Resources
Demonstrate the maintenance of Air Intake System of a DG set and also get a thorough understanding of the way to perform the activities.	2 hours	Diesel Generator , Air Filter Primary element, Standard Toolkit containing Tester, Screwdriver, Plier, Insulation Tape etc., Clean Cloth.

Method to do this activity

1. Refer page 123 of the participant handbook.
2. Go through the steps mentioned in the participant hand book.
3. Demonstrate the way to open up the air filter unit.
4. Remove the air filter primary element and show how to replace this element.
5. Explain the way Choke indicator works and show various indicators on the Choke indicator.
6. Describe the way to open and clean the dust accumulated in the evacuator valve.
7. Close the Air Filter unit and put the DG back in action.

Engine Fuel System Maintenance

Say

"Give a diesel engine clean fuel and it will run forever." This old saying is less of an exaggeration than you might think. Repair statistics show that 90% of diesel engine problems stem from contaminated fuel. This promise of eliminating 9 out of 10 potential failures should put fuel-system maintenance at the top of your list.

Elaborate

Revise the construction of the Engine Fuel System in front of the participants. Refer page 86 of the participant handbook to explain the utility of each part of this system. Also explain the mandatory precautions which need to be taken while maintaining the Engine fuel system by referring page 123.

Demonstrate

- Open the Engine Fuel System and demonstrate the way to do this.

Engine Fuel System

Activity

- This is a skill practice activity to demonstrate the Maintenance of the Engine Fuel system of a Diesel Generator at a tower site. This activity will provide complete knowledge on the activities to be undertaken to perform the maintenance of the Engine Fuel System.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all the points during this interaction.
- Details of the skill activity are given below.

Skill Practice	Time	Resources
Demonstrate the maintenance of Engine Fuel System of a DG set and also get a thorough understanding of the way to perform the activities.	2 hours	Diesel Generator, Primary Fuel Filter element and secondary fuel filter element, Standard Toolkit containing Tester, Screwdriver, Plier, Insulation Tape etc., Clean Cloth.

Method to do this activity

1. Refer page 123 -125 of the participant handbook.
2. Go through the steps mentioned in the participant handbook.
3. Demonstrate the way to open up the fuel filter unit.
4. Clean the primary and secondary fuel filter element with clean diesel or kerosene.
5. Shows the way to replace these filter elements.
6. Explain the use of the drain screw to remove the impure diesel from the fuel filter.
7. Demonstrate the process of cleaning the bowl thoroughly with kerosene or diesel.

Air Locking in Engine Fuel System

Activity

- This is a skill practice activity to demonstrate the maintenance of the engine fuel system of a diesel generator at a tower site by demonstrating how to remove Air locking from the fuel pipes. This activity will provide complete knowledge on the activities to be undertaken to perform the maintenance of the engine fuel system.

- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all the points during this interaction.
- Details of the skill activity are given below.

Skill Practice	Time	Resources
Demonstrate the maintenance of Engine Fuel System of a DG set and also get a thorough understanding of the way to perform the activities.	2 hours	Diesel Generator, Primary Fuel Filter element and secondary fuel filter element, Standard Toolkit containing Tester, Screwdriver, Plier, Insulation Tape etc., Clean Cloth.

Method to do this activity

1. Refer page 123 -125 of the participant handbook.
2. Go through the steps mentioned in the participant handbook.
3. Demonstrate the way to open up the Fuel filter unit.
4. Clean the Primary and Secondary fuel filter element with clean diesel or kerosene.
5. Shows the way to replace these filter elements.

Lubricant System Maintenance

Elaborate

Refer page 87 of participant's handbook and explain the types of Lubrication Systems. Review the parts of the Lubrication system as shown in the figure below(Refer to Figure 3.4.1).

1. Oil Pressure Gauge Conn
2. Pressure relief Valve
3. Oil Pump
4. Oil drain Plug
5. Oil Strainer
6. Dipstick
7. Oil Filter
8. Bypass Valve
9. Oil Filler Cap

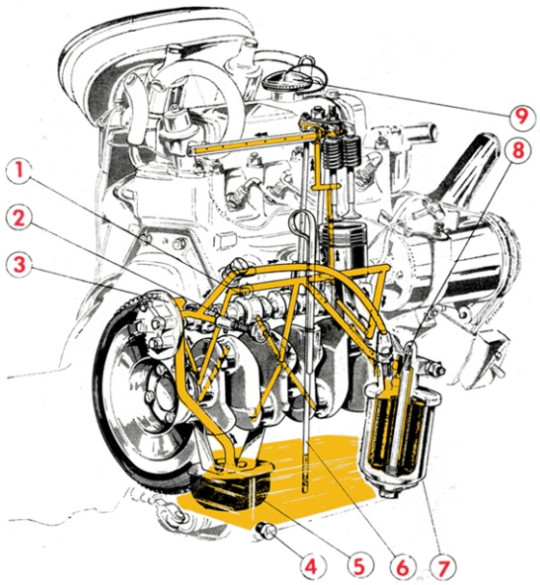


Fig. 3.4.1 Lubrication System

Ask

- Ask few questions on the Lubrication System from the participants to get an idea of the understanding they have got about this system. Explain again if they have any doubts.

Say

- Oil Filter is used to clean the Lubricant oil flowing in the engine. Since oil filter removes dust and other particles from the oil, after some time there is a need to replace this oil filter. The following activity explains how to perform this corrective maintenance function.

Activity

- This is a skill practice activity to demonstrate steps involved in Oil Filter Replacement of a Diesel Generator at a tower site. This activity will provide complete knowledge on how to replace the Oil Filter and the precautions need to be taken while replacing this filter.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all the points during this interaction as this activity they have to perform multiple times while maintaining the site.
- Details of the skill activity are given below.

Skill Practice	Time	Resources
Demonstrate the steps involved in the replacement of the Oil Filter and the precautions which need to be taken while doing this activity at site. After this activity you should be completely aware of the process of replacement of the oil filter.	2 hours	Diesel Generator, Oil Filter element, Sealing Ring, Standard Toolkit containing Tester, Screwdriver, Plier, Oil filter wrench etc., Clean Cloth.

Method to do this activity

1. Open the Diesel Generator Engine.
2. Focus your attention on the lubrication system.
3. Refer page 129 (Steps: Oil Filter Replacement) of the participants handbook.
4. Follow the steps as described in the participant handbook.
5. Close the DG set and it's ready for operations.

Say

After replacement of the Oil Filter, there is a requirement to change the lubricant oil in the engine. The following activity explains the steps to do that.

Activity

- This is a skill practice activity to demonstrate steps involved in refilling the lubrication oil in a Diesel Generator at a tower site. This activity will provide complete knowledge on how to refill the Lube oil and the precautions need to be taken while refilling the oil. This activity also explains the process of checking the Lube Oil level on regular basis using the dipstick.

- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all the points during this interaction.
- Details of the skill activity are given below.

Skill Practice	Time	Resources
Demonstrate the steps involved in the refilling of the lubricant oil and the precautions which need to be taken while doing this activity at site. After this activity you should be completely aware of the process of refilling of Lube Oil and also check the Oil level by using dipstick on regular basis.	2 hours	Diesel Generator, Oil Filter element, Sealing Ring, Standard Toolkit containing Tester, Screwdriver, Plier, Oil filter wrench etc., Clean Cloth.

Method to do this activity

1. Open the Diesel Generator Engine.
2. Focus your attention on the lubrication system.
3. Refer page 129 (Steps: Refilling of Lube Oil) of the participants handbook.
4. Follow the steps as described in the participant handbook.
5. Close the DG set and it's ready for operations.

Tappet Clearance for Air/Exhaust Valves

Say

Tappet Clearance is of utmost importance in a four stroke engine. It is a clearance between the Rocker arms and the point where they rest on the valves (top of the valve stem). Its purpose is to allow for some mechanical expansion and lengthening of the valve stem and push rods as the engine warms up. This clearance is also called Valve Rush. Usually both the surfaces are flat surfaces.

Elaborate

In a four stroke engine Rocker arms open and closes both inlet and outlet valves for Air and Exhaust flow to/from the engine. But there is no direct connection between the two. In fact Rocker just sits on the valve and then push rods moves the rocker arms thus the valves(Refer to Figure 3.4.2).

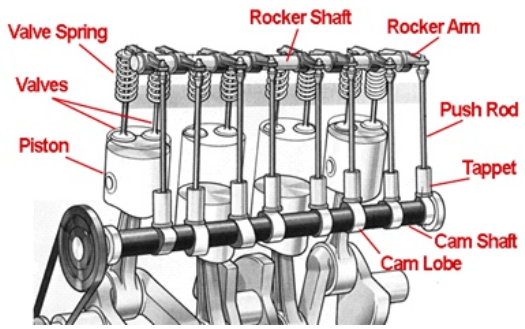


Fig. 3.4.2 Tappet Clearance

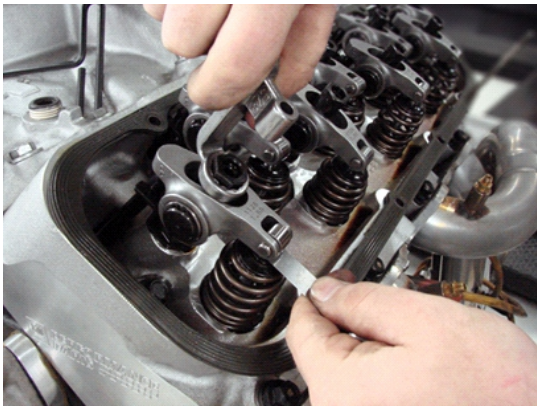


Fig. 3.4.3 Adjusting Tappet Clearance

What will happen if Tappet Clearance is less.

- Value will open early and close late.
- Air induced through Air inlet may leak out so less air for combustion.
- Power will be reduced.
- Fuel consumption will increase, engine may become unbalanced, exhaust temp will become very high.
- In worst condition valve may remain open resulting in loss of compression pressure thus burning of the exhaust valve and T/C fouling will increase.

What will happen if the Tappet clearance is more.

- Valve will open late and close early
- Lesser heat energy to T/C, so reduction in scavenge air and heat production
- No proper removal of gases
- Hammering of valve stem may cause damage to valve stem.

Adjusting Tappet clearance is one of the most important activities in generator maintenance, which is demonstrated below.

Activity

- This is a skill practice activity to demonstrate steps involved to perform tappet clearance adjustment of a Diesel Generator at a tower site. This activity will provide complete knowledge on how to do this adjustment and the precautions need to be taken while performing this important activity.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all the points during this interaction.
- Details of the skill activity are given below.

Skill Practice	Time	Resources
Demonstrate the steps involved in the Tappet clearance adjustment and the precautions which need to be taken while doing this activity at site. After this activity you should be completely aware of the process of doing this adjustment.	4 hours	Diesel Generator, Standard Toolkit containing Tester, Screwdriver, Plier, wrench, feeler gauge etc., Clean Cloth.

Method to do this activity

1. Take all safety precautions.
2. Make sure piston is on TDC (Top Dead Center).
   a. From marking of the flywheel
   b. From the fuel cam
   c. Push rod should be free (both the valve should be close at this stage i.e. at the end of compression stoke)
3. Make sure engine has cooled down.
4. Loosen the lock nut of the rocker arm.
5. Now adjust the Tappet clearance between the rocker arm and valve stem by tightening and losing the nut below lock nut.
6. Use the feeler gauge (Refer to Figure 3.4.5)to adjust this clearance depending on the specifications of the manufacturer. This feeler gauge should be placed inside the gap while adjusting the clearance through the nut (Refer to Figure 3.4.4). For best adjustment the feeler gauge should gently go out and in to get the best clearance (not too tight not so loose).

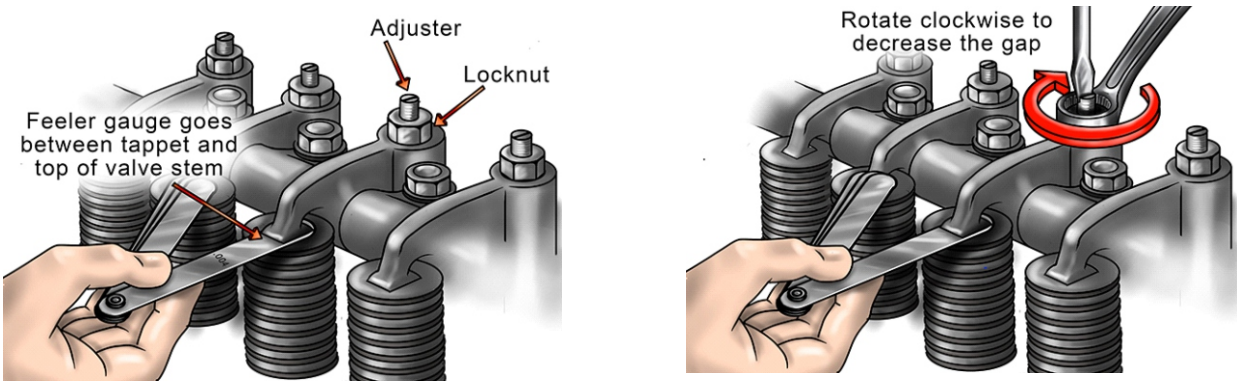


Fig. 3.4.4 Process of Adjusting Tappet Clearance

Fig. 3.4.5 Feeler gauge

Say

Once the Diesel Engine is working fine and Mechanical energy is getting generated by burning of fuel, this mechanical energy has to get transmitted to Alternator which converts the mechanical energy to Electrical energy. This transmission of mechanical energy from engine to alternator happened through V Belt (Refer to Figure 3.4.6 and 3.4.7) (V belt is designed to run in a pulley with a 60 degree V-groove. The V-groove transmits torque through a wedging action, thus increasing friction. They provide the best combination of traction, speed of movement, load of the bearings, and long service life).

Fig. 3.4.6 V Belt

Fig. 3.4.7 Replacing V Belt

Since V Belt is used regularly, wearing out of this belt is a common problem faced while maintaining a Diesel Generator. In such a case replacement of V belt has to be undertaken. The process to do this is explained in the activity below.

Activity

- This is a skill practice activity to demonstrate steps involved to perform V belt replacement of a Diesel Generator at a tower site. This activity will provide complete knowledge on how to replace this belt and the precautions need to be taken while performing this important activity.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all their points during this interaction.
- Details of the skill activity are given below

Skill Practice	Time	Resources
Demonstrate the steps involved in replacement of a V belt and the precautions which need to be taken while doing this activity at site. After this activity you should be completely aware of the process of doing this activity	4 hours	Diesel Generator, Standard Toolkit containing Tester, Screwdriver, Plier, wrench, feeler gauge etc., Clean Cloth. V belt.

Method to do this activity

1. Take all safety precautions.
2. Refer page 130 of the participant's handbook.
3. Maintenance of V belt involves three types of activities which are
    a. Checking the V belt
    b. Adjusting the V belt
    c. Replacing the V belt
4. Check the tension in the V belt by pressing the V belt, it should be as defined in the technical manual of the generator.
5. Inspect both sides of the V belt, if it's groves are becoming smooth and shiny, replace the belt.
6. Also inspect the crankshaft/ pulley for any glazing of the surface. In case you find that replacement of crankshaft/ pulley need to be performed.
7. While different generators has specific procedures to change/ adjust the v belt which can be looked at from the maintenance manual but we should demonstrate this on one of the DG set so that participant get a clear understanding of this important process.

Activity

- This is a skill practice activity to demonstrate various other maintenance activities of a diesel generator to be performed by site technician at a tower site. This activity will provide complete knowledge of maintenance of a diesel generator and the precautions need to be taken while performing this important activity.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all their points during this interaction.
- Details of the skill activity are given below.

Skill Practice	Time	Resources
Demonstrate various other maintenance activities to be performed on a diesel generator and the precautions which need to be taken while doing this activity at site. After this activity you should be completely aware of the process of doing these activities.	4 hours	Diesel Generator, Standard Toolkit containing Tester, Screwdriver, Plier, wrench, feeler gauge etc., Clean Cloth, various spare parts as needed.

Method to do this activity

1. Refer page 132 of the participant's handbook and go through the table showing various other maintenance activities.
2. Perform each activity step by step as given in the table.
3. Ensure that all the participants develop expertise in performing these activities.

UNIT 3.5: Maintenance of the Tower & Shelter

Unit Objectives

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

- Understand the activities to be performed under Preventive Maintenance of Tower & Shelter.
- Make their beat as per the company's policies.

UNIT 3.5.1: PM Schedule of the Tower & Shelter

Say

- Overall hygiene of the shelter and the overall tower site is something which needs to be looked at regular basis.
- In order to achieve this preventive maintenance and Corrective Maintenance at the site has to be performed regularly by the technician at site.
- Following activity will demonstrate the maintenance schedule of tower and shelter.

Activity

- This is a skill practice activity to demonstrate various maintenance activities to be performed by site technician at a tower site while maintaining Tower and shelter. This activity will provide complete knowledge of maintenance of a tower and shelter. Also the precautions need to be taken while performing these important activities.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all their points during this interaction.
- Details of the skill activity are given below.

Skill Practice	Time	Resources
Demonstrate various other maintenance activities to be performed at a shelter/ tower and the precautions which need to be taken while doing this activity at site. After this activity you should be completely aware of the process of doing these activities.	4 hours	Diesel Generator, Standard Toolkit containing Tester, Screwdriver, Plier, wrench, feeler gauge etc., Clean Cloth, various spare parts as needed.

Method to do this activity

1. Refer page 133 of the participant's handbook and go through the table showing various other maintenance activities.
2. Perform each activity step by step as given in the table.
3. Ensure that all the participants develop expertise in performing these activities.

UNIT 3.6: Maintenance of AC Plant

Unit Objectives

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

- Understand the activities to be performed under preventive and corrective maintenance of AC plant
- Make their beat plan as per the company's policies
- Perform practical exercises to get exposure to required maintenance activities for a AC plant

UNIT 3.6.1: Maintenance a Schedule of AC Plant

Say

- Overall hygiene of the AC plant is something which needs to be looked at regular basis.
- In order to achieve this, preventive maintenance and corrective maintenance at the site has to be performed regularly by the technician at site.
- Following activity will demonstrate the maintenance schedule of AC plant.

Activity

- This is a skill practice activity to demonstrate various maintenance activities to be performed by site technician at a tower site while maintaining AC plant. This activity will provide working knowledge of maintenance of an AC plant. This will also discuss the precautions need to be taken while performing these important activities.
- Ask the students to assemble together and form a group.
- Explain to them what we are going to do in this practical exercise.
- Tell all the students to clarify all the points during this interaction.
- Details of the skill activity are given below

Skill Practice	Time	Resources
Demonstrate various other maintenance activities to be performed for an AC plant and the precautions which need to be taken while doing this activity at site. After this activity you should be completely aware of the process of doing these activities.	4 hours	Diesel Generator, Standard Toolkit containing Tester, Screwdriver, Plier, wrench, feeler gaugeetc., Clean Cloth, various spare parts as needed.

Method to do this activity

1. Refer page 135 of the participant's handbook and go through the table showing various other maintenance activities.
2. Perform each activity step by step as given in the table.
3. Ensure all participants develop expertise in performing these activities.

UNIT 3.7: Maintenance of AMF/PIU

Unit Objectives

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

- Understand the activities to be performed under preventive and corrective maintenance of AMF/ PIU.
- Make your own beat plan as per your company's maintenance policy.
- Perform practical exercises to get exposure to required maintenance activities for AMF/PIU.

UNIT 3.7.1: Maintenance Schedule of AMF/PIU

Say

- Power Interface Unit/Auto Main Failure Unit is used to convert three phase power supply from the Electricity Board to a stabilized 230 V AC power supply. All the surges coming from the electricity board gets removed at the PIU. This output AC power from PIU is fed to the SMPS power unit which provides a stable DC power output.
- AMF is an automatic switch over to generator/ Battery backup incase AC mains from the Electricity Board fails. This is a Microprocessor based system which senses the electricity failure and switches over to a different power source. This is also called ATS (Automatic Transfer Switch).
- In order to achieve uptime of PIU/AMF preventive maintenance and corrective maintenance at the unit has to be performed regularly by the technician at site.
- Following activity will demonstrate the maintenance schedule of the AMF/ PIU

Activity

- This is a skill practice activity to demonstrate various maintenance activities to be performed by site technician at a tower site while maintaining PIU/ AMF. This activity will provide good working knowledge of maintenance of a PIU/ AMF. This activity will also discuss about the precautions need to be taken while performing these maintenance activities.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all their points during this interaction.
- Details of the skill activity are given below

Skill Practice	Time	Resources
Demonstrate various other maintenance activities to be performed for a PIU/ AMF and the precautions which need to be taken while doing this activity at site. After this activity you should have a good working knowledge of the process of performing these activities.	4 hours	PIU/ AMF, ACPDB, SMPS Unit, DCPDB, Input AC Power, Standard Toolkit containing Tester, Screwdriver, Plier, wrench, feeler gauge etc., Clean Cloth, various spare parts as needed.

Method to do this activity

1. Refer page 137-138 of the participant's handbook and go through the table showing various other maintenance activities.

2. Perform each activity step by step as given in the table.
3. Configure the parameters of the PIU/ AFM as per the table provided.
4. Ensure that all the participants develop expertise in performing these activities.

UNIT 3.8: Maintenance of SMPS Power Plant

Unit Objectives

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

- Understand the activities to be performed under preventive and corrective maintenance of the SMPS power plant.
- make their beat as per the company's policies
- Perform practical exercises required for maintaining a SMPS power plant.

UNIT 3.8.1: Maintenance of SMPS Power Plant

Say

- SMPS power plant is installed to convert the AC power supply to a DC power supply at the required voltage at a telecom site.
- In order to achieve this, Preventive Maintenance and Corrective Maintenance at the site has to be performed regularly by the technician at site.
- Following activity will demonstrate the maintenance schedule of AC plant.

Activity

- This is a skill practice activity to demonstrate various maintenance activities to be performed by site technician at a tower site while maintaining a power plant. This activity will provide good working knowledge of maintenance of a SMPS power plant. This activity will also discuss about the precautions need to be taken while performing these maintenance activities.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Ask the students to clarify all their points during this interaction.
- Details of the skill activity are given below

Skill Practice	Time	Resources
Demonstrate various maintenance activities to be performed for maintaining a Power plant and the precautions which need to be taken while doing this activity at site. After this activity you should have a good working knowledge of the process of performing these activities.	4 hours	PIU/ AMF, ACPDB, SMPS Power Unit, DCPDB, Input AC Power, Diesel generator set, Standard Toolkit containing Tester, Screwdriver, Plier, wrench, feeler gauge etc., Clean Cloth, various spare parts as needed.

Method to do this activity

1. Refer page 139 of the participant's handbook and go through the table showing various other maintenance activities.
2. Perform each activity step by step as given in the figure 3.5.3.
3. Configure the parameters of the power supply unit as per the table provided.
4. Ensure that all the participants develop expertise in performing these activities.

Summarize

In this chapter students have learnt about

- Preventive and corrective maintenance of a tower site.
- Beat plan and the way it has to be executed.
- Timely resolution of the faults incurred at site.

Key Learning Outcomes

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

1. Escalate faults/issues at site to supervisor.
2. Fill the Preventive Maintenance checklist/report
3. Fill the Corrective Maintenance checklist/report
4. Accurately report diesel filling, electricity bill and DG reading.
5. Report any changes in the site or movement of any material.
6. Report theft if any from the site location
7. Report movement of staff to the supervisor

UNIT 5.1: Introduction to Task Report

Unit Objectives

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

1. Understand the concept of Task Reporting.
2. Discuss the need to Task Reporting.
3. Timely Report and record various activities happening at a site.

Notes for Facilitation

- You could ask the students about their knowledge and understanding of the concept Task Reporting. Why Task Reporting is important?
- Invite students to participate. Tell them to give a brief description of task reporting.
- Let there be a debate in the class on this concept. This will provide students in depth understanding of the meaning of Task Reporting and what is expected from them.

Say

- Task Reporting is presenting a written account of the result or performance of a task which is assigned to someone by superiors or authorities.
- In order to standardize collection of results or information from many people at different locations reporting formats or reports are created which are followed by everyone.
- These reports are collected and the collected information which helps in taking decisions.
- In the following pages we will discuss various reporting formats which will be used by the participants to report daily activities at their site.

UNIT 5.2: Site Check List

Unit Objectives

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

1. Develop an understand the reporting formats and structures
2. Get well versed with the record keeping formats and the SLAs as per company policy.
3. Update all information about the site at one place.
4. Discuss the format of daily reporting
5. Record all activities at site on daily basis.

UNIT 5.2.1: Tower Site Audit Check List

Say

- This checklist is the first step towards record keeping at any tower site/ location
- This is used to track all the information about the site, location, contact details
- Equipment installed, type, make, model and serial number of the equipment
- Expansion capacity of the site for future planning

Do

- Open the check list in from of the participants
- Fill in all the information step by step
- Explain all points to participants so that they understand this exercise completely.

UNIT 5.2.2: Daily Tower Site Maintenance Check List

Say

- This checklist is the next step towards record keeping at any tower site/ location
- This is used to track all the activities done at site on daily basis
- This also records the status of key parameters on daily basis

Do

- Open the check list in from of the participants
- Fill in all the information step by step
- Explain all points to participants so that they understand this exercise completely

UNIT 5.3: Alarm Management Reporting

Say

- This reporting sheet is used to track the progress of resolution of an alarm/ fault by field O&M person or by operator incase resource sharing is happening at a site.
- Records are entered in this sheet as soon as any fault is reported at a site.
- This sheet is circulated to various senior team members who can also look at the progress of the fault resolution and points out if there are delays.

Do

- Open the check list in from of the participants
- Fill in all the information step by step
- Explain all points to participants so that they understand this exercise completely.

UNIT 5.4: Preventive Maintenance Reporting

Say

- These reporting sheets are used to record the Preventive Maintenance schedule and actual Preventive Maintenance activity at a tower site.
- The parameters of all equipment are recorded and activities to be performed every 15 days, 30 days and 90 days are clearly depicted.
- This sheet records Preventive Maintenance Activities, observations and other Corrective Maintenance Activities.
- Name of the technician, engineer and in charge is also recorded for every activity.

Do

- Open the check list in from of the participants
- Fill in all the information step by step
- Explain all points to participants so that they understand this exercise completely.

UNIT 5.5: Acceptance Testing Report

Say

- This reporting format is used at the time of site is getting installed and as soon as site is ready for handover acceptance testing report is to be submitted.
- It provides the complete status of all the components at the site at the time of acceptance testing.
- This sheet is kept in records and can be checked incase of any requirement

Do

- Open the check list in from of the participants
- Fill in all the information step by step
- Explain all points to participants so that they understand this exercise completely

UNIT 5.6: Fuel and Energy Management Report

Say

- This report records the diesel consumption and energy usage at a tower site.
- This also tracks the % performance of DG set and any Open reduction measures taken at the site.
- Records of EB bills are also maintained in this reporting sheet.

Do

- Open the check list in from of the participants
- Fill in all the information step by step
- Explain all points to participants so that they understand this exercise completely

Ask

- Bring out some questions to check the understanding of students

UNIT 5.7: Outage Analysis Report

Say

- This report records the diesel consumption and Energy usage at a tower site
- This also tracks the % performance of DG set and any Opex reduction measures taken at the site
- Records of EB bills are also maintained in this reporting sheet

Do

- Open the check list in from of the participants
- Fill in all the information step by step
- Explain all points to participants so that they understand this exercise completely

Ask

- Bring out some questions to check the understanding of students

UNIT 5.8: Outage Management Report

Say

- Outage management report is used to keep a detailed description of any outages happening at a site. This has many reporting formats which are described below.
  - Daily critical Activity – Site Visit Report
  - Material Requirement Plan – Any material required for doing maintenance
  - Escalation matrix- for any fault whom to connect and in what time frame.
  - FMC Log (Fault Management and Commissioning Log)- this tracks the duration of the call open time.
  - Incident Report – reporting any incident leading to need of monetary settlement.
- This also records the downtime of the site and the reason for such a downtime.

Do

- Open the check list in from of the participants
- Fill in all the information step by step
- Explain all points to participants so that they understand this exercise completely

Ask

- Bring out some questions to check the understanding of students

UNIT 5.9: Site Equipment Data Management

Say

1. This reporting format is used to records the details of equipment present at various sites. There are two types of reports in this:
   - Monthly Active Equipment Status Report (Master) – this list down additional equipment's which are installed at site to take care of additional requirements.
   - Equipment Maintenance plan – reports maintenance activity on each equipment.

Do

- Open these reports in front of the participants one by one
- Fill in all the information discussed step by step in the reporting format
- Explain all the points to the participants so that they can understand this exercise completely

Ask

- Bring out some questions to check the understanding of students

UNIT 5.10: Battery Testing Report

Say

- Many tests are performed on batteries for efficient working and long life. In this section we are discussing two reports
  - Boost Charge Report
  - Battery Backup test on System Load.
- Guidelines to perform battery backup test are also provided in this subunit.
- Use these reports in continuation of unit 3.3 – Maintenance of Batteries

Do

- Open the check list in from of the participants
- Fill in all the information step by step
- Explain all points to participants so that they understand this exercise completely

Ask

- Bring out some questions to check the understanding of students.

Summarize

In this chapter students have learnt about

- The concept of task reporting.
- How to keep the record of all the activities at site on daily basis.
- How to escalate the faults or issues occurred at the site.
- Tracking the progress of resolution of an alarm or fault.

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Council

3. Manage Site Operations safely and hygienically

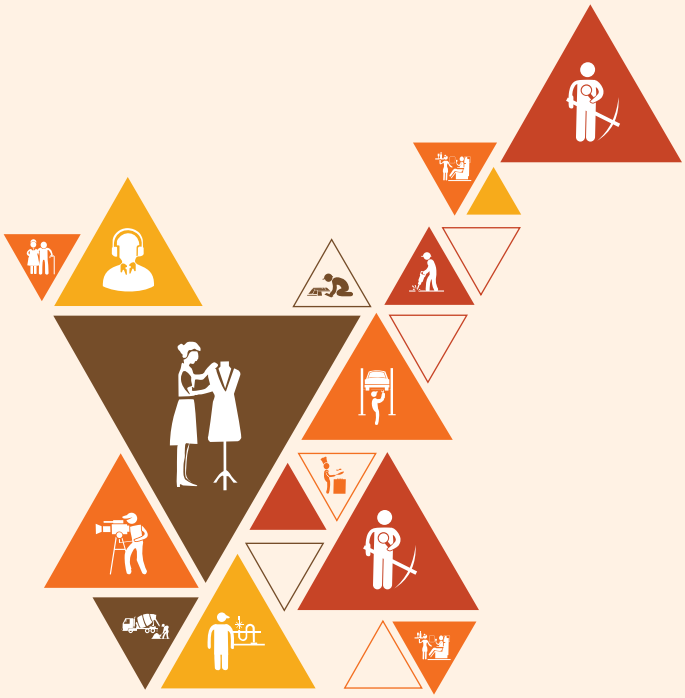
Unit 3.1 - Site Management Activities

Unit 3.2 - Waste Management at Site

Unit 3.3 - Operating Equipment at Site

Unit 3.4 - Fault Management System

Unit 3.5 - Escalation Procedure for Fire Accident



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Key Learning Outcomes

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

1. Monitor reading as per EB (electricity bill) against reading on PIU (power interface unit).
2. Timely collect and submit the EB (electricity bill) at the office.
3. Operate key equipment at site.
4. Check number of alarms active at the site.
5. Check site for faulty alarms.
6. Attend alarms within the defined SLA.
7. Identify the reason for site lock.
8. Co-ordinate with service providers for quality fuel to be filled.
9. Interact with site owners w.r.t. rent, access issues etc.

UNIT 3.1: Introduction to Site Management

Unit Objectives

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

1. Explain the process of site management.
2. Understand day to day site management activities.
3. Interact with the electricity board and ensure timely payment of their bills.
4. Maintain healthy relationship with landlord and ensuring your's organization needs and landlord's requirements are met timely.
5. Coordinate with the fuel filing vendors.
6. Understand the process of interaction with other authorities.

Notes for Facilitation

- You could ask the students about their knowledge and understanding about the concept of management.
- Invite students to participate. Tell them to give a brief description of management.
- Let there be a debate in the class and link the concept of management with management of site. This will provide students to understand the meaning of site management.

UNIT 3.1.1: Site Management Activities

Say

- Management is the process of dealing/interacting with or controlling things and people to achieve desired objectives.
- Term site management is the process of dealing and interacting with people, personals and authorities to achieve the organization's objectives for the site.

Do

- Explain to the participants the need of getting the processes understood properly during this session so that when on field the sites can be managed properly.
- Clarify all their doubts.

Explain

Talk about various types of interactions and activities which are to be performed on day to day basis for proper operation of the site like.

- Electricity Board Interaction
- Interaction and management of the landlord.
- Activities involving fuel filling vendors.
- Coordination with other authorities

UNIT 3.1.2: Electricity Board (EB) Intention

Say

Cordial relationship and timely payments of Electricity Board and its staff is needed from the tower technician for proper operations of the site. Following activity provides details of what need to be done by the personal at site.

Activity

- This is a skill practice activity to understand the activities to be performed with the Electricity board.
- Ask the students to assemble together and form groups.
- Encourage students to ask questions so that they can understand properly.
- Details of the skill activity are given below

Skill Practice	Time	Resources
To get acquainted with the processes and check list of the activities to be performed with electricity board	4 hours	Projector, Board and marker, slide showing the activities to be performed.

Method to do this activity

- Refer page 145 of the participant handbook
- Project Figure 4.1.1 in front of the participant
- Step by step discuss all the activities mentioned in the table
- Explain the importance of each activity
- Project flowchart from figure 4.1.2 on the screen
- Discuss how Electricity boards are organized
- Talk about the SLA s required to achieve various talks and escalation matrix within the organization
- Clarify all doubts of the participants

UNIT 3.1.3: Landlord Interaction

Say

Most of the tower sites are rented sites where the site owners control the activities happening at site by controlling the access to site. It is needed that in case of any shifting of material, downtime or visit of any official, employees to the site, there should be no access issues. Usually the activities which are performed with the site owner are

- Access Management
- Increase in site sharing
- Rental Payment
- Rental Revision

Activity

- This is a skill practice activity to demonstrate the process of interaction with the Landlord on day to day basis. Understand the SLA's and organization escalation matrix.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Details of the skill activity are given below

Skill Practice	Time	Resources
To acquaint with the process of interaction with the Landlord, understand the escalation matrix and the committed SLAs which need to be met.	3 hours	Projector, Board and marker, slide showing the activities to be performed.

Method to do this activity

- Refer page 149-153 of the participant handbook.
- Project Figure 4.1.3 to 4.1.6 in front of the participant.
- Step by step discuss all the activities mentioned in the table
- Explain the importance of each activity.
- Talk about the SLA s required to achieve various talks and escalation matrix within the organization.
- Clarify all doubts of the participants.

UNIT 3.1.4: Fuel Vendor Interaction

Say

- Site Management activities include interaction with fuel filling vendors on day to day basis as and when diesel is required to be filled. The tower technician present at the site also needs to interact with them regularly to ensure that there is enough fuel at the site and also to ensure that the payment to the vendors is made on timely basis. He has to submit the invoices with vendor bills and various other details as mentioned in the activity below and then follow to ensure timely payment of the vendor.

Activity

- This is a skill practice activity to demonstrate the process of interaction with the Fuel filling vendor as needed. Understand the SLA's and organization escalation matrix.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Details of the skill activity are given below

Skill Practice	Time	Resources
To acquaint with the process of interaction with fuel filling vendor, ensure timely payments and understand the escalation matrix and the committed SLAs which need to be followed.	3 hours	Projector, Board and marker, slide showing the activities to be perfor-med

Method to do this activity

- Refer page 154 of the participant handbook.
- Project Figure 4.1.7 in front of the participant.
- Step by step discuss all the activities mentioned in the table
- Explain the importance of each activity.
- Talk about the SLA s required to achieve various talks and escalation matrix within the organization.
- Clarify all doubts of the participants.

UNIT 3.1.5: Statutory Approvals

Say

- Site Management activities include interaction with other local statutory authorities. The tower technician present at the site also needs to interact with these authorities to sort out in case of any development.

Activity

- This is a skill practice activity to demonstrate the process of interaction with the Statutory Authorities as needed. Understand the SLA's and organization escalation matrix.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Details of the skill activity are given below

Skill Practice	Time	Resources
To acquaint with the process of interaction with the statutory authorities for various approvals, understand the escalation matrix and the committed SLAs which need to be met.	3 hours	Projector, Board and marker, slide showing the activities to be performed.

Method to do this activity

- Refer page 155 of the participant handbook.
- Project Figure 4.1.8 in front of the participant.
- Step by step discuss all the activities mentioned in the table
- Explain the importance of each activity.
- Talk about the SLA s required to achieve various talks and escalation matrix within the organization.
- Clarify all doubts of the participants.

UNIT 3.2: Waste Management at site

Unit Objectives

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

1. Understand the concept of waste management.
2. Differentiate between types of waste generated at the site.
3. Identify actions need to be taken to dispose off this video.

Say

- Lot of waste gets generated at any tower site which needs to be disposed off properly and timely to ensure that the hazardous waste is not accumulated at the site.
- Waste material if accumulated at site can lead to accidents like fire, explosions etc.
- This can lead to loss of human capital and equipment at site

Do

- Demonstrate the process of waste management at the tower site. Also provide an update on how to dispose this waste generated at site.
- Talk about the responsibilities as who is responsible for which activity.

Elaborate

- Refer page 156 of the participant handbook.
- Display Figure 4.2.1 in front of the participant.
- Step by step discuss all types of wastes as mentioned in the table
- Explain the importance of each activity.
- Clarify all doubts of the participants.

UNIT 3.3: Operating Equipment at Site

Unit Objectives

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

1. Understand the procedure to start a DG Set
2. Perform the steps to transfer the load on DG
3. Perform the steps to stop a DG Set
4. Operate the Fire Extinguisher at site

Say

- After human interaction proper management and operation of equipment at a site is another important parameter of site management.
- While technicians have gained expertise on technical details earlier, in this unit we will cover operational procedure of frequently used equipment.

UNIT 3.3.1: Operation of a DG Set

Do

1. Demonstrate the process of
   - Starting of a DG Set
   - DG Load transfer procedure
   - Stopping of a DG set

Activity

- This is a skill practice activity to demonstrate the operating process of a DG set.
- Ask the students to assemble together and form groups.
- Explain to them what we are going to do in this practical exercise.
- Details of the skill activity are given below

Skill Practice	Time	Resources
To acquaint with the operating procedure of a DG set.	1 hours	PIU/ AMF, ACPDB, SMPS Power Unit, DCPDB, Input AC Power, Diesel generator set, Standard Toolkit containing Tester, Screwdriver, Plier, wrench, feeler gauge etc, Clean Cloth

Method to do this activity

- Refer page 157 of the participant handbook.
- Step by step discuss all the activities mentioned.
- Demonstrate these activities on the test setup.
- Explain the importance of each activity.
- Ask questions to check the understanding of the participants.

UNIT 3.3.2: Operational Procedure of a Fire Extinguisher

Say

- Incase of fire at site immediate action by the technician present at site can save life and equipment deployed.
- This quick action will depend on the presence of mind and working knowledge of the person at site.
- We have earlier discussed about various types of fire extinguishers which can be used at various types of fire.
- Co2 based fire extinguishers are most commonly used at the tower site.

Do

- Demonstrate the process of using a Co2 based fire extinguisher.
- Take proper precautions as it can induce a situation of lack of Oxygen as Co2 replaces oxygen.

Elaborate

- Refer page 158 of the participant handbook.
- Step by step discuss the procedure of using these extinguishers.
- Explain the precautions which need to be taken while doing this activity.
- Discuss the escalation procedure in case of a fire.
- Clarify all doubts of the participants.

Ask

- Check the understanding of the participants by asking them questions on the topics.

UNIT 3.4: Fault Management System

Unit Objectives

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

1. Understand the concept of Network Management and fault management.
2. Describe the architecture of the fault management system.
3. Identify the component of a fault management system.
4. Understand how alarms get routed to various interface.
5. Explain the back end system used in Fault Management.

Say

- We discussed various types of Human interaction and Equipment Management as initial two pillars for proper operation of a site.
- Third pillar of site management is proper usage and understanding of fault management system for regular operation of a site.

Do

- Refer page 159 of the participant handbook
- Provide overview of Fault Management to all the participants
- Talk about need of fault management while doing site management of a site
- Discuss and explain various terms which are used in Fault management system
- Elaborate on fault management architecture, students should develop understanding about the basic architecture
- Explain the concept of network notification and event flow
- Display figures 4.4.3 to 4.4.7 in front of students and ensure that students get good understanding of Fault management internals and FM back end

Elaborate

- Display fig 4.4.8 and 4.4.9 in front of participants
- Discuss all major alarms present at a site
- Explain the importance of each alarm and the actions to be taken in case of those alarms

Ask

- Check the understanding of the participants by asking them questions on the topics

Summarize

In this chapter students have learnt about

- Site management processes.
- Fault management system and its operation

Notes

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5. Plan work effectively Organize Resources and Implement safety Practices

Unit 5.1 – Work Place Health and Safety
Unit 5.2 – Different types of Health Hazards
Unit 5.3 - Importance of safe working Places
Unit 5.4 - Reporting Safety Hazards
Unit 5.5 - Waste Management
Unit 5.6 - Organization's focus on Greening of Jobs

TEL/N9101

Key Learning Outcomes

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

1. Explain about workplace health and safety
2. understand different types of health hazards
3. Demonstrate various first-aid techniques
4. Understand the importance of safety at workplace
5. understand basic hygiene practices and hand washing techniques
6. Explain the need for Social Distancing
7. Understand the hazard reporting methods at workplace
8. Explain e-waste and process of disposing them
9. Explain the greening of jobs

UNIT 5.1: Workplace Health and Safety

Unit Objectives

At 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

Resources to be Used

- Participant handbook, white board marker pen, notebook, whiteboard, flipchart, laptop, overhead projector, laser pointer, etc.

Notes

- In this unit, we will discuss about workplace health & safety.

Say

Good morning and welcome back to this training program on Telecom E-Waste Handler.
In this session, we will discuss about workplace health & safety practices.

Ask

Ask the trainees the following questions:

- What do you understand by workplace safety?

Write down the trainees' answers on the whiteboard/flipchart.
Draw appropriate cues from the answers and start teaching the lesson.

Say

In this session, we will discuss the following points:

- Safety: Tips to design a safe workplace
- Non-Negotiable employee safety habits

Let us participate in an extempore activity to understand this unit better.

Activity

- This activity will be based on individual performance.
- Provide each trainee with a printout/Xerox copy of the safety hazard report
- Now ask each of them to fill up the report individually
- After completing, collect all the forms and evaluate them
- End the session by providing constructive feedback

Activity	Duration (in mins)	Resources Used
Role-play – Safety Hazard Report	40 minutes	Participant handbook, whiteboard, notebook, laptop, pen, pencil, marker, printout/Xerox copy of safety hazard report, etc.

Do

- Ensure that the report contains all possible hazards in the workplace, safety measures, and ways to counter the hazards if they occur
- Guide the trainees throughout the activity
- Ask the trainees if they have any questions
- Encourage other trainees in the class to answer it and encourage peer learning in the class
- Explain the consequences of not following the safety guidelines at the workplace

UNIT 5.2: Different types of Health Hazards

Unit Objectives

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

1. Understand the health hazards
2. Demonstrate First Aid Techniques

Resources to be Used

- Participant handbook, pen, notebook, whiteboard, markers, flipchart, laptop, overhead projector, laser pointer, equipment and tools, safety signs and symbols, safety equipment

Notes

- In this unit, we will discuss about different types of health hazards and first aid techniques

Say

- Good morning and welcome back to this training program on Telecom E-Waste Handler. In this session, we will discuss about different types of health hazards.

.

Ask

Ask the trainees the following questions:

- What is a health hazard?
- Can you name any health hazards that may occur at the workplace?

Write down the trainees' answers on the whiteboard/flipchart.
Draw appropriate cues from the answers and start teaching the lesson.

Notes for Facilitation

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

Explain the first aid techniques for injuries due to various causes. For burns, electric shock, fracture due to accidental fall etc.
Explain the concept of CRP and give a demonstration using a video how to administer CRP for a patient suffering a heart attack.
Through a demonstration explain the use of various safety gadgets used in the workplace.

Say

In this session, we will discuss the following points:

- First aid
- First aid techniques
  - For burns
  - For broken bones and fractures
  - For heart attack/stroke
  - For head injury
- Using breathing apparatus
- Briefing and guidance for firefighters
- Evacuation process
- Special evacuation requirements for specially-abled persons
- Importance of fire safety drills

Let us participate in an activity to understand this unit better.

Activity

- This session will be in the form of a "Show and Explain " activity.
- In this activity, bring a few PPE (relevant to the job role) to the class and demonstrates each of them - safety helmet, safety goggles, gloves, ear muff, respirator, harness, safety boots, etc.
- Now ask the trainees to identify the PPE and state their usage
- After the session, you will select a few volunteers and make them wear PPEs.
- The focus of this activity is to select and use appropriate personal protective equipment compatible with the work and compliant with relevant occupational health and safety guidelines.

Activity	Duration (in mins)	Resources Used
Practical activity - PPE	40 minutes	Participant handbook, laptop, overhead projector, internet connection, various protective equipment like safety helmet, safety goggles, gloves, ear muff, respirator, harness, safety boots, etc.

Do

- Ensure that all trainees participate in the activity
- Share your inputs and insight to encourage the trainees and add to what they talk about

Summarize

- Ask the participants what they have learnt so far.
- Ask if they have any questions related to what they have talked about so far.
- Close the discussion by summarizing the different health hazards and video demo of how to wear the PPE kits and first aid techniques.

UNIT 5.3: Importance of safe working practices

Unit Objectives

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

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

Resources to be Used

- Participant handbook, pen, notebook, whiteboard, flipchart, markers, laptop, overhead projector, laser pointer, etc.

Notes

- In this unit, we will discuss about the importance of safe working practices.

Say

Good morning and welcome back to this training program on Telecom E-Waste Handler.
In this session, we will discuss about the importance of safe working practices

Ask

Ask the trainees the following questions:

- List a few personal hygiene tips that you regularly follow.
- How social distancing helps to reduce the spread of Covid 19?
- What are the various covid protocols people followed during the pandemic?

Write down the trainees' answers on the whiteboard/flipchart.
Draw appropriate cues from the answers and start teaching the lesson.

Elaborate

In this session, we will discuss the following points:

- Basic hygiene practices
    - Personal hygiene
    - Personal hygiene practices at home
- Importance of social distancing
    - Social distancing and isolation
    - Self-quarantine
    - Disposing off the PPE kits
- Safe workplace practices
    - Supplies and Accessories in the first aid box
    - CPR

Say

- Let us participate in a practical activity to understand this unit better.

Notes for Facilitation

- Familiarize the trainees with the first aid box and the supplies inside it.
- Explain the importance of first aid and why is it good to know how to administer CRP for a patient who has suffered a heart attack.
- Answer all the questions/doubts raised by the trainees in the class
- Encourage other trainees to answer queries/questions and boost peer learning in the class

Practical

- Gather all the trainees in the laboratory and divide them into groups of two
- Ask each group to demonstrate the correct process for performing CRP
- Ensure the students follow all the steps of CPR in the correct sequence
- This activity can also be performed on a dummy, if available

Activity	Duration (in mins)	Resources Used
Practical activity – CPR	60 minutes	Participant handbook, whiteboard, notebook, laptop, pen, marker, dummy (if available), etc.

Do

- Prepare in advance and use appropriate energisers
- Encourage the students to explore how the training session can help them improve their work
- Keep the ambience constructive and positive
- Ensure each contribution is given fair consideration

Exercise

1. Burnt area should be kept under **cold water** for a minimum of 10 minutes
2. **Emergency exits** should be easily accessible in case of fire
3. **Antiseptic cream or Solution** must be applied to the wound to reduce the skin infection
4. The RICE which is Rest, Ice, Compression and Elevation therapy must be applied to control and reduce swelling.
5. CPR is **Cardio Pulmonary Resuscitation**

UNIT 5.4: Reporting Safety Hazards

Unit Objectives

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

1. Discuss the process of reporting in case of emergency (safety hazards)
2. Understand methods of reporting hazards

Resources to be Used

Participant handbook, pen, notebook, whiteboard, flipchart, markers, laptop, overhead projector, laser pointer, etc.

Say

Good morning and welcome to this training program on Customer Care Executive (Repair Centre)
In this session, we will discuss about reporting safety hazards.

Ask

Ask the trainees the following questions:

- What is a safety hazard?

Write down the trainees' answers on the whiteboard/flipchart.
Draw appropriate cues from the answers and start teaching the lesson.

Elaborate

In this session, we will discuss the following points:

- Methods of reporting safety hazards
- Describing hazard matrix
- Hazard report form

Say

Let us participate in an activity to understand this unit better.

Notes for Facilitation

- Explain the trainees about reporting the safety hazards to the people concerned.
- Explain the 6C's of communication protocols followed in the organizations.
    - Communicate First
    - Communicate Rightly
    - Communicate Credibly
    - Communicate Empathetically
    - Communicate to instigate appropriate action
    - Communicate to promote respect
- Explain about the Hazard report form
- Ask the trainees if they have any questions
- Encourage other trainees to take part in the activity and encourage peer learning in the class
- Discuss the exercises at the end of the chapter in the Participant Handbook and encourage them to answers.

Activity

- Divide the class into small groups
- Conduct a quiz and ask questions related to the unit
- Display all questions on the projector screen
- Display the correct answer after all groups have got their chances of answering a given question

Activity	Duration (in mins)	Resources Used
Quiz – Interpreting Signs	40 minutes	Laptop, internet connection, overhead projector, white screen, whiteboard, markers, laser pointer

Do

- Ask a student to maintain the scores on the whiteboard
- Jot down the crucial points on the whiteboard as the students speak
- Share your inputs and insight to encourage the students and add to what they talk about
- Ensure that all students participate in the class
- Ask a student to summarise what was discussed in the session
- Demonstrate enthusiasm for the subject matter, course and participant's work

UNIT 5.5: Waste Management

Unit Objectives

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

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

Resources to be Used

- Participant handbook, pen, notebook, whiteboard, flipchart, markers, laptop, overhead projector, laser pointer, etc.

Say

Good morning and welcome back to this training program on Telecom Customer Care Executive (Repair Centre).
In this session, we will discuss about waste management.

Ask

Ask the trainees the following questions:

- What do you understand by waste management?
- What are the sources of medical waste?

Write down the trainees' answers on the whiteboard/flipchart.
Draw appropriate cues from the answers and start teaching the lesson.

Elaborate

In this session, we will discuss the following points:

- Introduction to e-waste
  - What is e-waste?
- Electronic goods/gadgets are classified under three major heads
- E-waste management process
- Recyclable and non-recyclable waste
- Colour codes of waste collecting bins
- Waste disposal methods
- Sources of waste
- Source of Pollution
- Types of Pollution – Air, Water, Soil, Noise, Light

Say

Let us participate in an extempore activity to understand this unit better.

Activity

- This activity will be based on individual performance.
- In this activity, you will give two topics to the trainees
- The first topic in this session will be air pollution.
- The second topic on which the trainees will prepare their extempore will be on waste disposal method.
- You will randomly pick up trainees and separate them into two groups.
- Ensure that the trainees are equal in number.
- Allot the trainees 2 minutes to prepare the topic you will give them.
- After the time is up, you will call out any trainee and ask them to speak on the topic for 5 minutes.
- The trainee, with a simple explanation but rich content, will be appreciated with accolades.

Activity	Duration (in mins)	Resources Used
Extempore	40 minutes	Participant Handbook, Whiteboard, Notebook, Pen, Pencil, Marker, etc.

Do

- Do a de-briefing of the activity
- Conduct a doubt clarification session if needed.
- Encourage the quiet and shy trainees to open up and speak

Notes for Facilitation

- Encourage other participants to answer it and encourage peer learning in the class
- Answer all the doubts in case any of the participants

UNIT 5.6: Organization's focus on Greening of Jobs

Unit Objectives

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

1. Understand the concept of ESG
2. Explain the different factors of ESG

Resources to be Used

- Participant handbook, pen, notebook, whiteboard, flipchart, markers, laptop, overhead projector, laser pointer, etc.

Say

Good morning and welcome back to this training program on Telecom Customer Care Executive (Repair Centre).
In this session, we will discuss about greening of Jobs

Ask

Ask the trainees the following questions:

- What is ESG?

Write down the trainees' answers on the whiteboard/flipchart.
Draw appropriate cues from the answers and start teaching the lesson.

Elaborate

In this session, we will discuss the following points:

- What is ESG?
  - ESG stands for Environmental, Social, and Governance.
  - Environmental, social, and governance (ESG) investing refers to a set of standards for a company's behaviour used by socially conscious investors to screen potential investments.
  - Investors are increasingly applying these non-financial factors as part of their analysis process to identify material risks and growth opportunities.
- Factors of ESG
  - Environmental
  - Social
  - Governance

Say

Let us participate in a group discussion to explore the unit a little more.

Activity

- Conduct a group discussion in the class on the factors of ESG
- Ask the participants what they have learnt from this exercise
- Ask if they have any questions related to what they have talked about so far
- Close the discussion by summarising the importance of the ESG in recent times

Activity	Duration (in mins)	Resources Used
Group Discussion	45 minutes	Participant Handbook, Whiteboard, Notebook, laptop, Pen, Pencil, Marker, microphone and speakers etc.

Do

- Do a de-briefing of the activity
- Conduct a doubt clarification session if needed.
- Encourage the quiet and shy trainees to open up and speak
- Ensure a friendly and cordial atmosphere during the group discussion
- Give chance to each and everybody to give their opinion
- Guide the students in identifying key points

Notes for Facilitation

- Encourage other participants to answer it and encourage peer learning in the class
- Answer all the doubts in case any of the participants
- Discuss the proper combination technique in group discussion
- Make sure everybody understood the concept of greening of Jobs

Ask

- If they can, why can't you?
- Discuss concepts related to 'Creativity and Innovation' with the participants as given in the Participant Handbook.

Say

- Recall the stories on motivation.
- What is the inner drive that motivates people to succeed?
- Let's learn more about such creative and innovative entrepreneurs with the help of an activity.

Team Activity

- This is a group activity.
- Think of any one famous entrepreneur and write a few lines about him or her.

Activity De-brief

- Why did you choose this particular entrepreneur?
- What is his/her brand name?
- What creativity does he/she possess?
- What was innovative about their ideas?

Do

- Conduct a doubt clarification session if needed.
- Encourage the non-participating trainees to open up and speak

Summarize

- Summarize the unit by asking participants if they know of some people who are highly creative and innovative in their approach.
- Ask them to share some experiences about these people with the class.

Notes for Facilitation

- Source for stories on innovations:

http://www.rediff.com/getahead/report/achievers-top-31-amazing-innovations-from-young-Indians/20151208.htm

Exercise

1. ESG stands for **Environmental, Social Governance**
2. Governance factors include **Tax stategy, structure of the company , relationship with the stakeholders**
3. The three causes of air pollution are **emission from the car, dust particles and factories emitting chemical dust**
4. Mining waste includes **chemical gases emitted from mine blasting**
5. Landfill is a **waste that can't be recycled or reused**
6. **Blue, Black and Green** coloured bins are used in disposing the waste
7. Plastic cans are trashed in **blue bin**
8. **computer parts, mobile devices and electronic appliances** 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 **lead, mercury, toxic material and gas**

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5. Communication & Interpersonal Skills

Unit 5.1 - Interaction with supervisors, peers and Customers

Unit 5.2 - Explain the importance of developing sensitivity towards differently abled people

Key Learning Outcomes

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

1. Understand what communication is and the importance of communication in the workplace
2. Understand effective communication and how to communicate effectively for success
3. Discuss types of communication - verbal and non-verbal
4. Communicate at workplace
5. Communicate effectively with superiors
6. Communicate effectively with colleagues and customers using different modes viz face-to-face, telephonic and email communication
7. Understand the hurdles to effective communication
8. Conduct professionally at the workplace
9. Respect differences in gender and ability
10. Communicate effectively with a person with disabilities
11. Show respect for disabled people

UNIT 6.1: Interaction with supervisor, peers and customers

Unit Objectives

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

4. Understand the importance of communication
5. Understand types of communication

Resources to be Used

- Participant handbook, pen, notebook, whiteboard, flipchart, markers, laptop, overhead projector, laser pointer, equipment and tools

Notes

- In this unit, we will discuss how to communicate effectively with supervisor, peers and customers

Say

Good morning and welcome to this training program on Customer Care Executive (Repair Centre)
In this session, we will discuss about effective communication with supervisor, peers and customers

Ask

Ask the trainees the following questions:

- What is communication?
- What is non-verbal communication?
- What are the barriers to effective communication?

Write down the trainees' answers on the whiteboard/flipchart.
Draw appropriate cues from the answers and start teaching the lesson

Elaborate

In this session, we will discuss the following points:

- What is communication?
- Why is communication important?
- Effective communication
    - Effective communication for success
    - Significance of clear and effective communication
- Types of communication
    - Verbal communication
    - Non-Verbal communication
        - Signs and symbols
        - Gestures and expressions
- Communication at workplace
    - Communication with supervisors
    - Communication with colleagues & customers
    - Face-to-face communication
    - Telephonic communication
    - Email communication
- Importance of timely completion of tasks
- Standard operating procedure
- Escalation matrix
    - Escalation mechanism
    - Escalation through CRM
- Escalation Issues at work
    - What does it mean to escalate an issue at work?
    - When should you escalate an issue at work?
- Hurdles for effective communication
- Professional conduct
- Respect gender differences
- Communication with a disabled person
    - Communicating with people with a hearing impairment
    - Respect People with disability
    - Safety at the workplace for people with disability
        - Responsibilities of an employer towards disabled people
- Workplace adaptations for people with disability
    - Workplace adaptations

Say

In this session, we will discuss the following points:

Let us participate in the activity to understand all about effective communication

Activity

Scenario 1:

- This is an activity involving two. One volunteer as boss and the other as team member
- Provide the trainees with a scenario mentioned below
- You are the boss for a team of 15 members. You want to convey your displeasure regarding the performance of one of your team member. How would you convey this to him/her
- State what measures you will take to convey this matter to them.

Scenario 2:

- This is an activity involving two. One volunteer as boss and the other as team member
- Provide the trainees with a scenario mentioned below
- You are the boss for a team of 15 members. You want to appreciate one of your team mate's performance. He closed a big business deal of Rs.1 cr. How would you do?
- State what measures you will take to appreciate to them.

Activity	Duration (in mins)	Resources Used
Mock activity	60 minutes	Participant handbook, whiteboard, laptop, notebook, pen, pencil, marker, etc.

Do

- Ensure that all trainees participate in the class.
- Encourage the non-participating trainees to open up and speak.
- Do a de-briefing for this activity. You tell them, scolding is always done in private, one to one, whereas appreciation is always done in open in front of others, for them to feel happy about it and at the same time others get motivated to give their best performance.

Notes for Facilitation

- Ask them to answer the questions given in the participant manual.
- Ensure that all the participants answer every question.
- Answer all the doubts raised by the trainees in the class
- Discuss the proper communication technique in all the class activity

UNIT 6.2: Explain the importance of developing sensitivity towards differently abled people

Unit Objectives

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

3. Communicate Effectively with person with disabilities
4. Respect people with disability, at workplace

Resources to be Used

- Participant handbook, pen, notebook, whiteboard, markers, flipchart, laptop, overhead projector, laser pointer, equipment and tools

Notes

- In this unit, we will discuss about how to communicate effectively with people who has disabilties

Say

- Good morning and welcome back to this training program on Telecom Customer Care Executive (Repair Centre).
- In this session, we will discuss about how to communicate with people who are differently abled

.

Ask

Ask the trainees the following questions:

- What is an effective communication?
- Have they ever got an opportunity to help/assist a disabled person?

Write down the trainees' answers on the whiteboard/flipchart.
Draw appropriate cues from the answers and start teaching the lesson

.

Notes for Facilitation

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

As a co-worker, one should be empathetic with them and talk to them politely and with respect. Every work place has guidelines for handling these kinds of people. And all employees need to adhere to those guidelines.

Say

In this session, we will discuss the following points:

- What is a disability
- General tips for communication with disabled people
- Respect people with disability
- Work place safety for people with disability
- Work place adaptation by people with disability

Do

- Ensure that all trainees have understood the purpose of this module
- Encourage them to participate in the discussion

Summarize

- Ask the participants what they have learnt so far.
- Ask if they have any questions related to what they have talked about so far.
- Explain them how to interact with differently abled people, respect them and assist and support them to complete their work if need be.
- Learnt about effectively communicating with people who are differently abled.

Ask

- If they can, why can't you?
- Discuss concepts related to 'Creativity and Innovation' with the participants as given in the Participant Handbook.

Say

- Recall the stories on motivation.
- What is the inner drive that motivates people to succeed?
- Let's learn more about such creative and innovative entrepreneurs with the help of an activity.

Team Activity

- This is a group activity.
- Think of any one famous entrepreneur and write a few lines about him or her.

Activity De-brief

- Why did you choose this particular entrepreneur?
- What is his/her brand name?
- What creativity does he/she possess?
- What was innovative about their ideas?

Do

- Conduct a doubt clarification session if needed.
- Encourage the non-participating trainees to open up and speak

Summarize

- Summarize the unit by asking participants if they know of some people who are highly creative and innovative in their approach.
- Ask them to share some experiences about these people with the class.

Notes for Facilitation

- Source for stories on innovations:

http://www.rediff.com/getahead/report/achievers-top-31-amazing-innovations-from-young-Indians/20151208.htm

Do

Exercise Handling Strategy – The solution for the exercise is given as:

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

Fill in the blanks

1. Before sending the mail it's important to check the **grammar and spelling** of the content.
2. When you interact through phone, provide your identity details like **Name,company** and **department**
3. Add your **signature** at the bottom of your mail.
4. The Customer Care Executive is mainly responsible for handling **customer Queries**

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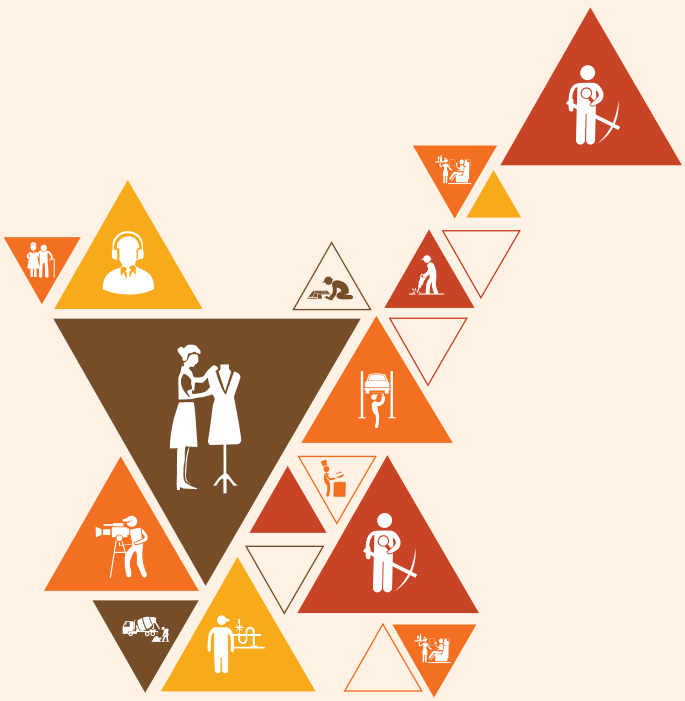
7. Annexures

Annexure I : Training Delivery Plan

Annexure II: Assessment Criteria

Annexure III: List of QR codes in PHB



Annexure I

Training Delivery Plan

Training Delivery Plan			
Program Name:	Tower Technician		
Qualification Pack Name & Ref. ID	TEL/Q4100, Version Number 4.0		
Version No.	4.0	**Version Update Date**	30/12/2021
Pre-requisites to Training (if any)	NA		
Training Outcomes	**After completing this programme, participants will be able to:** • Perform preventive and corrective maintenance at the tower • Optimize resources, work efficiently and adhere to safety standards • Interact effectively with others while being sensitive of gender and persons with disabilities		

Sl.NO.	Module Name	Session Name	Session Objectives	NOS Reference	Methodology	Training Tools/Aids	Duration (Hours)
1	Role and responsibilities of a Tower Technician	Role and responsibilities of a Tower Technician	• Describe the role and responsibilities of a Tower Technician • Explain the scope of work for a Tower technicianOutline the course objectives and outcomes • Identify the roles and responsibilities of a Tower Technician • Discuss the career progression of a Tower Technician in the Telecom industry • Explain the basics of telecom and the terminologies used in the work process	Bridge Module	Classroom lecture / Powerpoint Presentation / Question & Answer / Group Discussion	Whiteboard, Markers, Duster, Projector, Laptop, Presentation	30 T - 20 P - 10
2	Maintain tower site and report periodically	- Introduction to Components at a -Tower Site -PIU- Power Interface -Other Equipments -PIU- Power Interface Unit -EB Supply - Guidelines for Maintenance Activities -Routine Preventive Maintenance - Maintenance of Batteries	•Discuss the functions of various electrical/electronic components and ools/equipment used at the tower site •Discuss the importance and implications of maintenance activities at the tower site •Describe fault analysis procedures and safety measures for different tools and mechanical equipment • Distinguish between preventive and corrective maintenance •Explain the processes of preventive maintenance and corrective maintenance •Interpret the standard operating procedures while performing preventive and corrective maintenance and the escalation matrix •Discuss commonly occurring hazards while handling the battery bank, AC (access concentrator), DG (diesel generator), PIU (power interface unit), SMPS (switched mode power supply), shelter, etc. at the tower site; along with related/appropriate precautions to avoid them •List the do's and don'ts while installing a DG (Diesel Generator) and avoid common mistakes that occur during the process	TEL/N4138 PC1, PC2, PC3, PC4, PC5	Classroom lecture / Powerpoint Presentation / Question & Answer / Group Discussion	PIU, PMU, Battery Bank, AC Unit, SMPS, DG set, Tester, Multi-meter, Electrical tools, Megger, Service Level Agreement, Related SOPs, etc.	46 T - 20 P - 26

		- Maintenance of Diesel Generators - Maintenance of Tower & Shelter - Maintenance of AC Plant - Maintenance of AMF/PIU - Maintenance of Power Plant - Tower Side Audit Check List - Tower Side Maintenance Check List	• Demonstrate Boost charging of the cell • Inspect the Battery Bank, DieselGenerator, Air Conditioner, PIU (Power Interface Unit), and SMPS (Switched Mode Power Supply) to analyse for premature ageing and faults Perform the preventive and corrective maintenance of a DG, AC, PIU, SMPS, Tower and Shelter	TEL/N4138 PC6, PC7,PC8,PC9,PC 10			46 T-20 P - 27
		- Alarm Management Reporting - Preventive Maintenance Reporting - Acceptance Testing Report - Fuel and Energy Management Report - Outage Analysis Report - Outage Management Reporting - Site	Draft a report to escalate any faults or issues to the supervisor/authority. emonstrate the analyses and repair of recurring faults at the site Identify and fill requisite checklists fororrective and preventive maintenance	TEL/N4138 PC11,PC12,PC13 ,PC14,PC15,PC1 6			47 T - 20 P - 27

		Equipment Database Reporting					
3	Manage Site and Hygiene Site Operation	Site Management activities	•Distinguish between various features and functions of different power quipment. •Understand three phase electric power supply and methods to measure it • Outline the fundamentals of electric wiring • Understand the functioning of NOC (Network Operational Centre) and TOC	TEL/N4139 PC1 TILL PC8	Classroom lecture / Powerpoint Presentation / Question & Answer / Group Discussion	PIU, PMU, SPSM Battery Bank, AC Unit, Tester, multi meter and electrical tools, Megger	26 T - 10 P - 16
		Waste Management at Site	show multiple techniques to identify the faulty alarms and take corrective measures	TEL/N4139 PC9 TILL 15			26 T - 10 P - 16
		Operating Equipment at Site	•Describe various methods for monitoring civil and mechanical installations at the tower site • Identify and describe the components and various aspects of distribution panel. • Discuss various types of alarms and the procedures to examine them • Explain the functionalities and working of the sensors deployed on the site • Adhere to the standards and follow the check list while performing inspection	TEL/N4139 PC 12 – PC14			26 T - 10 P - 16
		Fault Management System	• Identify and interpret various floor markings, shadow board display and labels • State the importance of certifying the service vendors for quality work in time	TEL/N4139 PC16, PC17,PC18			26 T - 10 P - 16
		Escalation Procedure for Fire Accident	Demonstrate, as to how reading of the electricity bill can be captured and perform measuring and recording the fuel consumption	TEL/N4139 PC19, PC17,PC15			26 T - 10 P - 16

7	Organise resources and work effectively and safely	Perform work as per quality standards	•Employ appropriate ways to keep the workspace clean and tidy •Discuss how to perform individual roles and responsibilities as per the job role while taking accountability for the work •Show how to record/document tasks completed as per the requirements within specific timelines •Perform the steps to implement schedules to ensure the timely completion of tasks •Identify the cause of a problem related to your own work and validate it •Apply appropriate techniques to analyse problems accurately and communicate different possible solutions to the problem •Discuss how to comply with the organisation's	TEL/N9101 PC1, PC2, PC3, PC4, PC5, PC6	Classroom lecture / PowerPoint Presentation / Question & Answer / Group Discussion	Whiteboard/blackboard marker /chalk, Duster, Computer or Laptop attached to LCD projector, Personal Protection Equipment: Safety glasses, Head protection, Rubber gloves, Safety footwear, Warning signs and tapes, Fire extinguisher and First aid kit	6 T(2:00) P(4:00)
8		Maintain a safe, healthy and secure working environment (Part - 1)	current health, safety, security policies and procedures •Demonstrate the steps to check for	TEL/N9101 PC1, PC2, PC3, PC4, PC5, PC6, PC7, PC8, PC9, PC10, PC11, PC12, PC13, PC14			6 T(2:00) P(4:00)

			water spills in and around the workspace and escalate these to the appropriate authority •Practice reporting any identified breaches in health, safety, and security policies and procedures to the designated person •Use safety materials such as goggles, gloves, earplugs, caps, ESD pins, covers, shoes, etc. •Apply required precautions to avoid damage of components due to negligence in ESD procedures or any other loss due to safety negligence •Identify hazards such as illness, accidents, fires or any other natural calamity safely, as per the organisation's emergency procedures, within the limits of the individual's authority •Explain the importance of regularly participating in fire drills or other safety-related workshops organised by the company •Discuss the significance of reporting any hazard outside the individual's authority to the relevant person in line with organisational procedures and warn others who may be affected				

9		Maintain a safe, healthy and secure working environment (Part - 2)	•Explain how to maintain appropriate posture while sitting/standing for long hours •Employ appropriate techniques to handle heavy and hazardous materials with care while maintaining an appropriate posture •Discuss the importance of sanitising workstations and equipment regularly •Discuss how to avoid contact with anyone suffering from communicable diseases and take necessary precautions •Show how to clean hands with soap and alcohol-based sanitiser regularly •List the safety precautions to be taken while travelling, e.g., maintain a 1m distance from others, sanitise hands regularly, wear masks, etc. •Role-play a situation to report hygiene and sanitation issues to the appropriate authority •Discuss how to follow recommended personal hygiene and sanitation practices, for example, washing/sanitising hands, covering the face with a bent elbow while coughing/sneezing, using PPE, etc.	TEL/N9101 PC15, PC16, PC17, PC18, PC19, PC20, PC21, PC22			6 T(2:00) P(4:00)

10		Conserve material / energy / electricity	•Apply appropriate ways to optimise the usage of material, including water, in various tasks/activities/processes •Use resources such as water, electricity and others responsibly •Demonstrate the steps to carry out routine cleaning of tools, machines and equipment • Apply appropriate ways to optimise the use of electricity/energy in various tasks/activities/processes •Perform periodic checks of the functioning of the equipment/machine and rectify wherever required •Explain the significance of reporting malfunctioning and lapses in the maintenance of equipment •Use electrical equipment and appliances properly	TEL/N9101 PC23, PC24, PC25, PC26, PC27, PC28, PC29			6 T(2:00) P(4:00)
11		Use effective waste management / recycling practices	•Identify recyclable, non-recyclable and hazardous waste •Apply appropriate ways to deposit recyclable and reusable material at the identified location •Explain the process to dispose of non-recyclable and hazardous waste as per recommended processes	TEL/N9101 PC30, PC31, PC32			6 T(2:00) P(4:00)

12	Communication and interpersonal skills	Interact effectively with superiors	•Explain how to receive work requirements from superiors and customers and interpret them correctly •Role-play a situation to inform the supervisor and/or concerned person about any unforeseen disruptions or delays •Practice participating in decision-making by providing facts and figures, giving/accepting constructive suggestions •Practice rectifying errors as per feedback and ensure the errors are not repeated	TEL/N9102 PC1, PC2, PC3, PC4	Classroom lecture / PowerPoint Presentation / Question & Answer / Group Discussion	Whiteboard and Markers, Chart paper and sketch pens, LCD Projector and Laptop for presentations, Sample of escalation matrix, organisation structure	6 T(2:00) P(4:00)
13		Interact effectively with colleagues and customers (Part - 1)	•Discuss how to comply with the organisation's policies and procedures for working with team members •Apply appropriate modes of communication, such as face-to-face, telephonic and written, to communicate professionally •Show how to respond to queries and seek/provide clarifications if required	TEL/N9102 PC5, PC6, PC7			6 T(2:00) P(4:00)
14		Interact effectively with colleagues and customers (Part - 2)	•Illustrate the process to co-ordinate with the team to integrate work as per requirements •Discuss how to resolve conflicts within the team/with customers to achieve a smooth workflow •Discuss how to recognise emotions accurately in self	TEL/N9102 PC8, PC9, PC10, PC11			6 T(2:00) P(4:00)

			and others to build good relationships •State how to prioritise team and organisation goals above personal goals				
15		Gender sensitisation	•Explain how to maintain a conducive environment for all genders in the workplace •Discuss ways to encourage appropriate behaviour and conduct with people across gender •Explain how to ensure equal participation of people across genders in discussions	TEL/N9102 PC12, PC13, PC16			6 T(2:00) P(4:00)
16		PwD sensitisation	•Identify ways to assist team members with a disability in overcoming any challenges faced at work •Practice appropriate verbal and non-verbal communication while interacting with People with Disability (PwD)	TEL/N9102 PC14, PC15			6 T(2:00) P(4:00)
17	Employability Skills	DGT/VSQ/N0102 Employability Skills		DGT/VSQ/N0101			60 hrs

Total Duration	**Theory Duration** 210 **Practical Duration** 210
On the Job Training (Training provied by the relevant industry)	120
Employability Skills (DGT/VSQ/N0102) (https://eskillindia.org/NewEmployability)	60
Total Duration (Theory+Practical+OJT+ES)	540

Annexure II – Assessment Criteria

CRITERIA FOR ASSESSMENT OF TRAINEES

Assessment Criteria for "Tower Technician "	
Job Role	Tower Technician
Qualification Pack	TEL/Q4100
Sector Skill Council	Telecom Sector Skill Council

Guidelines for Assessment

1. Criteria for assessment for each Qualification Pack will be created by the Sector Skill Council. Each Performance Criteria (PC) will be assigned marks proportional to its importance in NOS. SSC will also lay down proportion of marks for Theory and Skills Practical for each PC.
2. The assessment for the theory part will be based on knowledge bank of questions created by the SSC.
3. Assessment will be conducted for all compulsory NOS, and where applicable, on the selected elective/option NOS/set of NOS.
4. 4a. Individual assessment agencies will create unique question papers for theory part for each candidate at each examination/training center. (as per assessment criteria below).
   4b. Individual assessment agencies will create unique evaluations for skill practical part for every student at each examination/training center based on this criterion.
5. To pass the Qualification Pack, every trainee should score a minimum of 70% of aggregate marks to successfully clear the assessment.
6. In case of successfully passing only certain number of NOS's, the trainee is eligible to take subsequent assessment on the balance NOS's to pass the Qualification Pack.

Assessment Outcomes	Assessment Criteria for Outcomes	Theory Marks	Practical Marks	Project Marks	Viva Marks
TEL/N4138: Maintain tower site and report periodically	*Perform preventive maintenance activities at the tower site*	**15**	**25**	**-**	**10**
	PC1. interpret PM (Preventive Maintenance) plan for proper execution	2	1	-	1
	PC2. comply with preventive maintenance schedule	2	1	-	1
	PC3. conduct site PM (Preventive Maintenance) as per standards	2	2	-	1
	PC4. maintain site up-time as per SLA	2	1	-	1
	PC5. check battery banks for faulty cells and replace as per guidelines	2	5	-	1
	PC6. check earthing system and fix the faults	2	5	-	1
	PC7. monitor site outages and link failures	2	5	-	2
	PC8. check premature ageing of Battery Bank, Diesel Generator, Air Conditioner, PIU and SMPS	1	5	-	2
	Perform corrective maintenance of equipment	**5**	**10**	**-**	**5**
	PC9. identify the malfunction that require corrective maintenance	2	3	-	1
	PC10. perform fault analysis to identify and repair/replace components which may lead to a fault	1	2	-	1
	PC11. diagnose reasons of downtime through uptime analysis	1	3	-	1
	PC12. repair recurring faults on sites	1	2	-	2
	Create and submit reports	**10**	**15**	**-**	**5**

	PC13. prepare preventive and corrective maintenance checklists and reports	3	4	-	2
	PC14. record activities like diesel filling, electricity bill and DG meter reading, etc.	2	4	-	1
	PC15. inform the supervisor regarding changes in the site, movement of any material or theft, if any	2	3	-	1
	PC16. escalate faults/issues observed at site to the supervisor in the prescribed format	3	4	-	1
	NOS Total	**30**	**50**	**-**	**20**
TEL/N4139: Manage site operation safely and hygienically	*Manage regular site upkeep*	**5**	**10**	**-**	**-**
	PC1. maintain all power equipment as per standards	1	1	-	-
	PC2. monitor all civil and mechanical installations at the site	1	2	-	-
	PC3. check the number of active alarms at the site	-	1	-	-
	PC4. attend alarms within the defined SLA	1	1	-	-
	PC5. identify faulty alarms and take corrective action	1	1	-	-
	PC6. monitor infrastructure sensors and surveillance cameras	-	2	-	-
	PC7. remove unwanted materials from site to keep the premises clutter free	-	1	-	-

	PC8. ensure proper cleanliness and housekeeping at telecom sites	1	1	-	-
	Maintain safety and hygiene of the site	**15**	**15**	**-**	**5**
	PC9. maintain site hygiene of AC, DG, PIU, SMPS and battery bank, as per organization norms	3	5	-	1
	PC10. check leakage, rattles and shakes at the tower site	2	1	-	1
	PC11. ensure proper installation of fire safety instruments as per standards	2	1	-	1
	PC12. inspect the site as per electrical safety norms	2	1	-	1
	PC13. ensure proper floor markings, shadow board display and labels at the site	2	3	-	1
	PC14. conduct work area audit as per company checklists	2	2	-	-
	PC15. maintain checklist of standards laid by the company	2	2	-	-
	Manage site administration	**20**	**20**	**-**	**10**
	PC16. ensure quality fuel is filled by the service providers	5	6	-	3
	PC17. monitor EB (Electricity Bill) reading against the reading on PIU	5	4	-	3
	PC18. collect and submit the EB at the office	5	5	-	2
	PC19. supervise and certify vendor for quality and timely completion	5	5	-	2
	NOS Total	**40**	**45**	**-**	**15**

TEL/N9101: Organise Work and Resources as per Health and Safety Standards	*Perform work as per quality standards*	**4**	**9**	**-**	**2**
	PC1. keep workspace clean and tidy	-	1	-	-
	PC2. perform individual role and responsibilities as per the job role while taking accountability for the work	1	1	-	1
	PC3. record/document tasks completed as per the requirements within specific timelines	-	1	-	1
	PC4. implement schedules to ensure timely completion of tasks	-	2	-	-
	PC5. identify the cause of a problem related to own work and validate it	2	2	-	-
	PC6. analyse problems accurately and communicate different possible solutions to the problem	1	2	-	-
	Maintain safe, healthy and secure working environment	**16**	**27**	**-**	**4**
	PC7. comply with organisation's current	1	1	-	-

	health, safety, security policies and procedures				
	PC8. check for water spills in and around the work space and escalate these to the appropriate authority	1	2	-	1
	PC9. report any identified breaches in health, safety, and security policies and procedures to the designated person	1	2	-	1
	PC10. use safety materials such as goggles, gloves, ear plugs, caps, ESD pins, covers, shoes, etc.	1	2	-	1
	PC11. avoid damage of components due to negligence in ESD procedures or any other loss due to safety negligence	2	3	-	1
	PC12. identify hazards such as illness, accidents, fires or any other natural calamity safely, as per organisation's emergency procedures, within the limits of individual's authority	2	1	-	-
	PC13. participate regularly in fire drills	1	3	-	-

	or other safety related workshops organised by the company				
	PC14. report any hazard outside the individual's authority to the relevant person in line with organisational procedures and warn others who may be affected	1	3	-	-
	PC15. maintain appropriate posture while sitting/standing for long hours	1	1	-	-
	PC16. handle heavy and hazardous materials with care, while maintaining appropriate posture	1	1	-	-
	PC17. sanitize workstation and equipment regularly	1	2	-	-
	PC18. clean hands with soap, alcohol-based sanitizer regularly	-	1	-	-
	PC19. avoid contact with anyone suffering from communicable diseases and take necessary precautions	-	1	-	-
	PC20. take safety precautions while travelling e.g. maintain 1m distance from	1	2	-	-

	others, sanitize hands regularly, wear masks, etc.				
	PC21. report hygiene and sanitation issues to appropriate authority	1	1	-	-
	PC22. follow recommended personal hygiene and sanitation practices, for example, washing/sanitizing hands, covering face with a bent elbow while coughing/sneezing, using PPE, etc.	1	1	-	-
	Conserve material/energy/electricity	**7**	**16**	**-**	**3**
	PC23. optimize usage of material including water in various tasks/activities/processes	1	2	-	-
	PC24. use resources such as water, electricity and others responsibly	1	2	-	1
	PC25. carry out routine cleaning of tools, machine and equipment	1	2	-	-
	PC26. optimize use of electricity/energy in various tasks/activities/processes	1	3	-	1
	PC27. perform periodic checks of the	1	3	-	1

	functioning of the equipment/machine and rectify wherever required				
	PC28. report malfunctioning and lapses in maintenance of equipment	1	2	-	-
	PC29. use electrical equipment and appliances properly	1	2	-	-
	Use effective waste management/recycling practices	**3**	**8**	**-**	**1**
	PC30. identify recyclable, non-recyclable and hazardous waste	1	2	-	1
	PC31. deposit recyclable and reusable material at identified location	1	3	-	-
	PC32. dispose non-recyclable and hazardous waste as per recommended processes	1	3	-	-
	NOS Total	**30**	**60**	**-**	**10**
TEL/N9102: Interact Effectively with Team Members and Customers	*Interact effectively with superiors*	**7**	**15**	**-**	**2**
	PC1. receive work requirements from	1	2	-	-

	superiors and customers and interpret them correctly				
	PC2. inform the supervisor and/or concerned person about any unforeseen disruptions or delays	2	4	-	1
	PC3. participate in decision making by providing facts and figures, giving/accepting constructive suggestions	2	5	-	1
	PC4. rectify errors as per feedback and ensure the errors are not repeated	2	4	-	-
	Interact effectively with colleagues and customers	**7**	**26**	**-**	**4**
	PC5. comply with organisation's policies and procedures for working with team members	1	2	-	-
	PC6. communicate professionally using appropriate mode of communication such as face-to-face, telephonic and written	2	4	-	1
	PC7. respond to queries and seek/provide clarifications if required	2	4	-	1
	PC8. co-ordinate with team to integrate work as per requirements	-	3	-	-

	PC9. resolve conflicts within the team/with customers to achieve smooth workflow	1	5	-	1
	PC10. recognize emotions accurately in self and others to build good relationships	1	4	-	-
	PC11. prioritize team and organization goals above personal goals	-	4	-	1
	Respect differences of gender and ability	**11**	**24**	**-**	**4**
	PC12. maintain a conducive environment for all the genders at the workplace	2	5	-	1
	PC13. encourage appropriate behavior and conduct with people across gender	2	5	-	1
	PC14. assist team members with disability in overcoming any challenges faced in work	3	4	-	1
	PC15. practice appropriate verbal and non-verbal communication while interacting with People with Disability (PwD)	2	4	-	1
	PC16. ensure equal participation of the people	2	6	-	-

	across genders in discussions				
	NOS Total	**25**	**65**	**-**	**10**
DGT/VSQ/N0102: Employability Skills (60 Hours)	*Introduction to Employability Skills*	**1**	**1**	**-**	**-**
	PC1. identify employability skills required for jobsin various industries	-	-	-	-
	PC2. identify and explore learning and employability portals	-	-	-	-
	Constitutional values – Citizenship	**1**	**1**	**-**	**-**
	PC3. recognize the significance of constitutional values, including civic rights and duties, citizenship, responsibility towards society etc. andpersonal values and ethics such as honesty, integrity, caring and respecting others, etc.	-	-	-	-
	PC4. follow environmentally sustainable practices	-	-	-	-
	Becoming a Professional in the 21st Century	**2**	**4**	**-**	**-**
	PC5. recognize the significance of 21st CenturySkills for employment	-	-	-	-

	PC6. practice the 21st Century Skills such as Self-				
	Awareness, Behaviour Skills, time management, critical and adaptive thinking, problem-solving, creative thinking, social and cultural awareness, emotional awareness, learning to learn for continuous learning etc. in personal and professional life	-	-	-	-
	Basic English Skills	**2**	**3**	**-**	**-**
	PC7. use basic English for everyday conversationin				
	different contexts, in person and over the telephone	-	-	-	-
	PC8. read and understand routine information, notes,				
	instructions, mails, letters etc. written in English	-	-	-	-
	PC9. write short messages, notes, letters, e-mailsetc. in				
	English	-	-	-	-
	Career Development & Goal Setting	**1**	**2**	**-**	**-**
	PC10. understand the difference between job andcareer	-	-	-	-
	PC11. prepare a career development plan	-	-	-	-

	withshort- and long-term goals, based on aptitude				
	Communication Skills	**2**	**2**	**-**	**-**
	PC12. follow verbal and non-verbal communication etiquette and active listeningtechniques in various settings	-	-	-	-
	PC13. work collaboratively with others in a team	-	-	-	-
	Diversity & Inclusion	**1**	**2**	**-**	**-**
	PC14. communicate and behave appropriatelywith all genders and PwD	-	-	-	-
	PC15. escalate any issues related to sexual harassment at workplace according to POSH Act	-	-	-	-
	Financial and Legal Literacy	**2**	**3**	**-**	**-**
	PC16. select financial institutions, products andservices as per requirement	-	-	-	-
	PC17. carry out offline and online financialtransactions, safely and securely	-	-	-	-
	PC18. identify common components of salary and compute income, expenses, taxes, investments etc	-	-	-	-
	PC19. identify relevant rights and laws and uselegal aids to fight against legal exploitation	-	-	-	-

	Essential Digital Skills	3	4	-	-
	PC20. operate digital devices and carry out basicinternet operations securely and safely	-	-	-	-
	PC21. use e- mail and social media platforms andvirtual collaboration tools to work effectively	-	-	-	-
	PC22. use basic features of word processor,spreadsheets, and presentations	-	-	-	-
	Entrepreneurship	2	3	-	-
	PC23. identify different types of Entrepreneurshipand Enterprises and assess opportunities for potential	-	-	-	-
	business through research				
	PC24. develop a business plan and a work model, considering the 4Ps of Marketing Product, Price, Place and Promotion	-	-	-	-
	PC25. identify sources of funding, anticipate, andmitigate				
	any financial/ legal hurdles for the potential business opportunity	-	-	-	-
	Customer Service	1	2	-	-
	PC26. identify different types of customers	-	-	-	-
	PC27. identify and respond to customer	-	-	-	-

	requestsand needs in a professional manner.				
	PC28. follow appropriate hygiene and groomingstandards	-	-	-	-
	Getting ready for apprenticeship & Jobs	**2**	**3**	**-**	**-**
	PC29. create a professional Curriculum vitae(Résumé)	-	-	-	-
	PC30. search for suitable jobs using reliable offlineand online sources such as Employment exchange, recruitment agencies, newspapers etc. and job portals, respectively	-	-	-	-
	PC31. apply to identified job openings using offline /online methods as per requirement	-	-	-	-
	PC32. answer questions politely, with clarity and confidence, during recruitment and selection	-	-	-	-
	PC33. identify apprenticeship opportunities and register for it as per guidelines and requirements	-	-	-	-
	NOS Total	**20**	**30**	**-**	**-**

List of QR Codes in PHB

Chapter No	Unit No	Topic Name	Page No	QR Code
1	1.4	Components of a Cellular Network	24	Click the QR code to view the video on how a telecom tower works
2	1.5	Types of Telecom Towers	24	Click the QR code to view the video on types of telecom tower
3	2.1	Telecom tower and its components	30	Click the QR code to view the video on Telecom tower and its components
4	2.11	General Maintenance activities	151	Click the QR code to view the video

List of QR Codes in PHB

Chapter No	Unit No	Topic Name	Page No	QR Code
5	4.3	Importance of safe working practices (First Aid Techniques)	210	Click/Scan this QR code to view the video for First Aid at work place
6	4.3	Importance of safe working practices	218	Click/Scan this QR code to view the video on Hand Washing techniques
7	4.3	Importance of safe working practices	223	Click/Scan this QR code to view the video on CPR Techniques
8	4.5	Waste Management	229	Click/Scan this QR code to view the video on Waste Management
9	5.1	Types of Communication	239	Click/Scan this QR code to view the video on Types of Communication
10	5.1	Types of Communication	241	Click/Scan this QR code to view the video communication with Customer and colleagues
11	5.1	Types of Communication	242	Click/Scan this QR code to view the video on Effective Telephone Communication

Chapter No	Topic Name	QR Code
12	Employability Skill	Click/Scan the QR code to access e-Book on Employability Skills

Do

- Explain each Guideline for Assessment in detail
- Explain the score that each trainee needs to obtain
- Recapitulate each NOS one-by-one and take participants through the allocation of marks for Theory and Skills Practical.
- Explain the Allocation of Marks. Explain that they will be assessed on Theory and Skills Practical.
- Explain that for the first NOS, <22> marks are allotted for Theory and &<78>for Skills Practical.

Notes

Skill India
कौशल भारत-कुशल भारत

सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP

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