

ELECTRICAL AND FIRE HAZARDS

DIPLOMA COURSE

Course Code: 7442



Department of Nutritional Sciences & Environmental Design
Faculty of Sciences

ALLAMA IQBAL OPEN UNIVERSITY

ELECTRICAL AND FIRE HAZARDS

Postgraduate Diploma Course

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Prepared by Dr. Rabeea Zafar



Department of Nutritional Sciences and Environmental Design

Faculty of Sciences

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FOREWORD

It is with immense pride that we present a study guide for the Postgraduate Diploma in Environment, Health & Safety (EHS) at Allama Iqbal Open University. This program epitomizes our commitment to integrating environmental stewardship with effective and innovative EHS practices in tackling some of the most pressing challenges facing humanity in shaping a sustainable future.

EHS professionals play a crucial role in safeguarding the well-being of employees, the public, and the environment. As industries progress and new technologies emerge, EHS professionals face an ever-developing set of challenges. The PGD program is specially designed to provide students with the knowledge, skills, and practical insight needed to lead in such a dynamic field. Our curriculum integrates emerging technologies with sustainable EHS practices, hence responding not only to the current needs of the

industry but also to prevent and reduce accidents, emergencies, and health issues at the workplace, along with

any other environmental damage that could result from work practices. This includes the foundation, organizing, planning, monitoring and auditing of the EHS management system at the workplace. It will train the students as master trainers who will be able to protect the well-being of the workforce in their relevant domains of expertise and also ensure the environmental regulations that meet the employees' and workplace safety standards, which is necessary in current and future environmental demands.

This study guide serves as an overall map of courses that will make our students competent and forward-looking EHS professionals. It, therefore, outlines the course objectives, structure, and key components that will leave our students well-prepared for challenges with innovative, realistic, and sustainable solutions.

At Allama Iqbal Open University, we pride ourselves on being a hub of excellence in education and research. The PGD in EHS is proof of our continued quest to further knowledge and practice for the betterment of local and global communities. This course will be your guide on how to engage deeply with the environmental regulations and take up the challenge to a meaningful impact on EHS management system which in turn would help increase our country's compliance with various EHS regulations.

I wish all the best to all the students in this pursuit. This program may enrich and transform you into being one of the leaders in creating a sustainable and resilient future.

Warm Regards,

Prof. Dr. Nasir Mahmood
Vice Chancellor
Allama Iqbal Open University

PREFACE

Dear Students,

I welcome you to the PGD Environment, Health and Safety (EHS) offered by the Department of Nutritional Sciences and Environmental Design (NSED). I hope this message finds you all well.

As we start the study of “EHS”, I wanted to provide you all with a comprehensive guide to clear your understanding and preparation. EHS is crucial because it safeguards human well-being and the planet. Ensures compliance with regulations, preventing accidents, illnesses, and environmental harm. Reduces workplace risks, enhancing employee morale and productivity.

I encourage you to engage actively with the material, ask questions, and participate in discussions to deepen your understanding. Remember, our goal is not just to pass exams but to internalize this knowledge to ensure the safety of ourselves and those around us.

If you have any questions or need further clarification on any topic, feel free to reach out. Make safety our top priority as we explore this important subject.

Best Wishes,

Prof. Dr. Hajra Ahmed

MESSAGE FROM CHAIRMAN

Dear Students,

Welcome to the Department of Nutritional Sciences and Environmental Design's diploma program in Environment, Health, and Safety. I am pleased to announce the development of a comprehensive study guide focused on electrical and fire hazards.

This guide aims to equip all students with the necessary knowledge and protocols to identify, prevent, and respond to electrical and fire hazards effectively. Understanding these risks is essential not only for your safety but also for the protection of your facilities, equipment, and the broader community.

This initiative aligns with your professional and personal commitment to prioritizing safety and fostering a culture of awareness and preparedness. By educating on these critical topics, we not only mitigate risks but also contribute to a safer working environment for everyone.

I encourage all students to actively engage with the study guide and utilize its resources to enhance their understanding of electrical and fire safety. Together, we can create a workplace where safety is paramount, and emergencies are managed with confidence and competence.

Thank you for your attention to this important matter. If you have any questions or suggestions, please don't hesitate to reach out to the program coordinator.

Stay Safe, Stay Vigilant!

Best Wishes

Dr. Zaheer Ahmad
Chairman,

ACKNOWLEDGEMENT

All praises to **Allah**, who gave me the strength to complete this project. The development of this comprehensive study guide on "Electrical and Fire Hazards" has been a collaborative effort, drawing upon the expertise and support of numerous individuals. It gives me pleasure to express my profound gratitude and reverence to the Vice Chancellor of Allama Iqbal Open University, **Prof. Dr. Nasir Mehmood**, for guiding, facilitating, and supporting the preparation of the course. We extend our heartfelt gratitude to all those who have contributed to the creation of this resource.

I would like to express my sincere appreciation to **Prof. Dr. Hajra Ahmad**, Dean, Faculty of Sciences, for her support and encouragement. Thanks to **Dr. Zaheer Ahmed**, Chairman, Department of Nutritional Sciences and Environmental Design, for his sustenance and trust. All the faculty members, especially **Dr. Muhammad Farooq Mustafa**, Assistant Professor, Department of Nutritional Sciences and Environmental Design, **Ar. Nazia Iftikhar**, Lecturer, Department of Nutritional Sciences and Environmental Design, and **Ms. Warda Jehanzeb** being an expert in architecture, environmental design, and planning and sustainable development, provided valuable insights and guidance throughout this study guide's planning and development stages. Your expertise and dedication have been instrumental in ensuring the content's quality and relevance.

I also acknowledge the contributions of the design and editorial team, production, and printing team who worked diligently to ensure the clarity, coherence, and accessibility of the content presented in this study guide. Your dedication and attention to detail have been essential in bringing this resource to fruition.

Lastly, we extend our deepest appreciation to the post-graduate students who will use this study guide as a tool for learning and professional development. It is our sincere hope that it will serve as a valuable resource in your studies and practice of climate-responsive design and environmental sustainability.

Thank you to everyone who has contributed to the creation of this study guide. Your collaboration and support have been invaluable in making this project a reality.

Dr. Rabeea Zafar
Course Coordinator

INTRODUCTION TO THE STUDY GUIDE

Dear student,

We welcome you to the PGD in Environment Health and Safety course entitled “Electrical and Fire Hazards”. This course is part of your PGD program. For an introduction to the course please go through the guidelines provided here for successful completion.

Unit no. 1 describes the principles of electricity, and the types of dangers associated with electrical use at the workplace.

Unit no. 2 discusses the process involved in carrying out electrical risk assessments and analysis based on severity.

Unit no. 3 focuses on the control measures of hazards identified and the use of different equipment to control and minimize the risk of electrical hazards.

Unit no. 4 explains the principle and classification of fire hazards.

Unit no. 5 helps to understand the risk assessment process of fire hazard identification, and risk analysis based on hazard identification.

Unit no. 6 identifies techniques for storage of flammables, structural measurements involved in fire hazards, and link of electrical equipment with fire hazards.

Unit no. 7 defines the safe handling and storage of chemical substances.

Unit no. 8 demonstrates the evacuation procedures, emergency evacuations, and evacuation drills.

Unit no. 9 discusses the training on firefighting equipment, awareness about risks and hazards associated with electrical and fire use at the workplace, and the importance of maintenance of safety equipment to reduce the risks.

This subject addresses the concerns related to the electrical and fire hazards associated with the workplaces and how they can be mitigated through exploration and designing systems to reduce their frequency and probability to occur causing damage to human life.

It aims at key elements of fire safety that would be necessary in cases of protecting lives and properties when a fire emergency occurs. Advanced detection systems, access for evacuation, and immediate interventions will be effective in minimizing fire risks and impacts on emergencies. Topics covered include Fire Detection and Alarm Systems; Portable Fire Fighting Equipment; Access for Fire Evacuation; and Rescue Services.

This guide is meant for a comprehensive understanding of essential concepts, processes, and practices of fire risk management. No matter whether you are a practicing safety professional, facility manager, or new to this arena, this guide will impart you with the most desired knowledge required to effectively identify, mitigate, and then manage fire risks.

Best Wishes!

Dr. Rabeea Zafar
Course Coordinator

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UNIT-1

PRINCIPLES, HAZARDS, AND RISKS OF ELECTRICITY

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Reviewed by: Dr. Muhammad Farooq Mustafa

Ar. Nazia Iftakhar

INTRODUCTION

Electricity's origins trace back beyond Benjamin Franklin's famous kite experiment, with Alessandro Volta conducting early experiments in 1800, notably proposing the silver/zinc battery. Though unaware of its mechanism, Volta's work laid crucial groundwork. By 1807, Humphry Davy constructed a battery, advancing understanding. As history unfolded, discoveries revealed electricity's influence on compass needles, leading to the invention of the first electric generator. By 1860, efforts surged to create practical generators employing magnets. Fast forward to 1880, Thomas Edison's mastery of the incandescent light and the development of distribution systems marked a pivotal moment. Consequently, generators were installed just before 1900, ushering in electricity to commercial sectors in major cities, transforming society's landscape irreversibly.

Electricity is part of life nowadays. Everything, from simple household appliances to large and complex industrial systems, uses electricity. With many advantages, however, comes great hazards and risk, which have to be known and addressed. This unit explains the basics of electricity in relation to dangers from electrical systems and activities. In order to understand and apply knowledge safely, a professional or a student must have insight into such dangers.

OBJECTIVES:

The objectives of this unit are as follows:

1. To understand the fundamental principles of electricity and key concepts.
2. To identify and assess the hazards of electricity and the factors responsible for the severity of electrical injuries.

To evaluate the safety risk and mitigation strategies in order to reduce electrical risk at residential and commercial/ industrial settings

1.1 PRINCIPLES OF ELECTRICITY

In the most basic terms, electricity is the movement of electrons. The movement of electrons creates electric current or charge, which is harnessed (controlled and made use of) to do work like power a lightbulb.

1.1.1 What are the Components of an Electric Circuit?

Whenever you turn on your light, you are using an electric circuit. There are four basic parts to this circuit that all work together to provide you with the power you need: the AC or DC energy source, a conductor in the form of a wire, an electrical load and at least one controller, a switch.

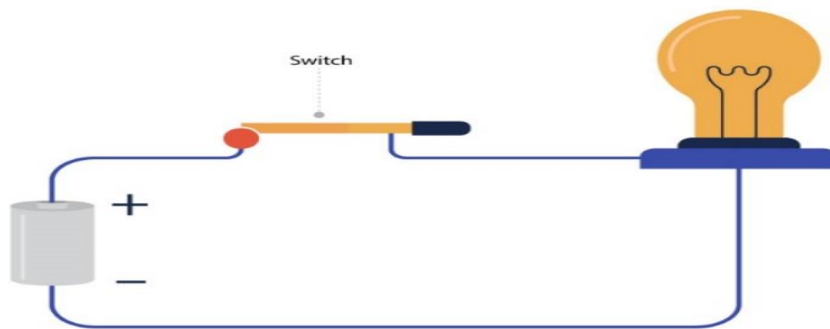


Figure 1.1: Electric circuit.

Think about what happens when you turn on a light; you push the switch. This causes electricity to flow through the wires to the power source, which will convert the energy to light or power.

Let us start with the energy source. In your circuit, the power sources will provide the voltage and current to energize your device. Then there is the conductor, which is the wiring in your home. This provides the path that the energy flows through and connects all the other parts of the circuit. Think of this as the electric power flowing through a pipe or a hose. Then you have the switch, which closes or opens the energy flow of the circuit. Put simply: this is the light switch. This allows the energy to move through, so you get power.

Finally, there is the load. The load is the amount of electrical energy your device needs to work. Think of your TV and your electric bill; that has to do with your load.

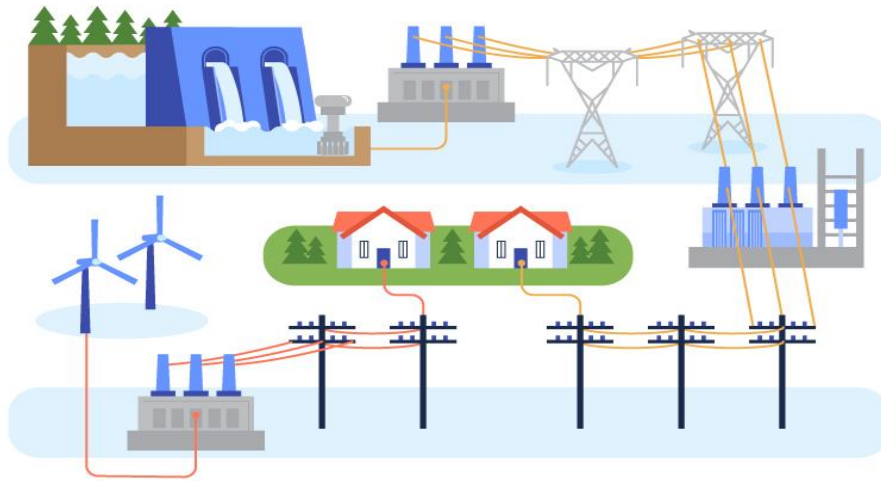


Figure 1.2: How Electric circuit works?

1.1.2 How Does it Work?

Let us discuss how each of them works for better understanding.

1.1.3 Passive Sign Convention

So, you have your passive components like your resistors, capacitors, and the ohm which establish a relationship between voltage and current. This helps make up the voltage polarity, which works with the current direction for two-terminal components. This is called the passive sign convention.

1.1.4 Resistive Circuits

When you have a circuit that only contains those ohms in the AC circuit, that is known as a resistive circuit. There will be inductance or capacitance in this kind of

circuit since the AC and voltage will both move forward and backward in the direction of the circuit.

1.1.5 Electromagnetic Fields

The differences in voltage will create electric fields. The higher the voltage, the stronger the field will be. Magnetic fields are created when the currents flow. The more current you have, the stronger the field. Together, these compose the electromagnetic field.

1.1.6 Electric Power in a Circuit

All the power you have in your circuit depends on the principles. This includes ohm and the relationship between voltage, current, and resistance.

1.1.6.1 Direct Current (DC)

Your DC current is the unidirectional flow of movement that the electrons go through. The intensity of the current can vary over time, but the direction of the current will never change.

1.1.6.2 Alternating Current (AC)

On the other hand, the alternative current will change direction. The flow of electric charge will sometimes move direction, especially if the sources vary periodically. This is used a lot with the commercial power that we often use.

1.1.7 How is it Generated?

Electric power is generated through a variety of sources. This includes hydroelectric power, electromagnetic power, as well as electric power created through combustion, such as the burning of fossil fuels.

1.1.7.1 Electric Generators

Electric generators supply energy to power any number of devices. While they do supply energy, they do not create the energy they transmit. Generators receive power from an outside source, whether it is hydraulic power, or that created from burning fossil fuels. The generator then takes this energy, and through an alternating current, delivers electricity to the device it is meant to power.

1.1.7.2 Electric Motors

Electric motors leverage the power of electromagnetic fields, whether they use alternating current (AC) or direct current (DC). These motors take in electrical power and convert it into usable, mechanical energy. This allows electric motors to create motion and power any range of appliances.

1.1.8 How is it Measured?

Electricity is measured in various ways. The most common methods of describing the amount of power produced by electrical energy are wattage, volts, and amperage. These each define a different aspect of electrical power, namely the amount of energy used, the pressure (also known as force) of the energy pushed through, and the amount of energy flowing through a circuit, respectively.

1.1.8.1 Wattage

Wattage is measured in Watts. It represents the amount of energy being used for an amount of time. Put otherwise; this is the volume of energy that is produced and used by a given device. Higher-wattage appliances use a larger volume of energy than those that have lower wattage. Watts are important when selecting different appliances and devices since energy companies often charge customers for the volume of kilowatts (or units of 1,000 watts) that are used during the period of a billing cycle. Reducing the overall wattage use in your household reduces your energy bills in turn.

1.1.8.2 Amperes

Amperes are measured in amperage, although they are sometimes simply called ‘amps’ for short. Amperage measures the amount of electricity that is flowing through a given circuit. Amperage can be tested with a tool called a multimeter, which determines the power of the current being pushed through the circuit.

Always use caution when testing a current, and ensure your multimeter is rated to handle the amps your circuit may produce. Measuring your amperage can help you diagnose a circuit that allows a stronger current flow than intended or determine a circuit that is causing excess power leakage.

1.1.9 Calculating Power

There are plenty of different ways to calculate power depending on the reason you need to calculate it. However, the equation is most simply put as the result of work and time is power. Vice versa, power is equal to the amount of work (W) over time (T). First, you must determine the value for Work, which is equal to Force multiplied by Distance.

Work Example

First, we will look at the equation to calculate power in its most simple form:

$$\text{Power (P)} = \text{Work (W)} \div \text{Time (T)}$$

For a practical example, let us assume our units of time are seconds, and the work is measured in volts. We will use 10 volts for work and measure the time as 2 seconds.

Power = $10\text{V} \div 2\text{s}$, therefore the Power (P) is equal to 5.

1.1.9.1 Power Ratings

Resistor power ratings grade a resistor on its ability to dissipate excess electrical energy safely. This energy is what is lost in the circuit and dissipated into the surrounding environment as heat. Ratings are given for the maximum wattage a resistor can safely dissipate while still maintaining proper functionality.

1.1.9.2 Resistor – Power Loss Culprits

Calculating the amount of power dissipation through a resistor is fairly simple, provided you know the amperes flowing through the circuit (labelled as I) and the ohm resistance (R).

$$\text{Resistor power loss} = I^2(R)$$

1.1.10 Efficient Use of Power

Using electrical power efficiently ensures not only a reduction in your electrical costs but also the continuation of natural resources. There are several ways to improve the way you use power, with many requiring very minimal effort.

If you plan on remodeling, smart materials that absorb and spread heat captured through sunlight should be used around windows and in naturally well-lit areas.

1.1.11 A Better Understanding

Electricity, the flow of electric current along a conductor, powers our daily lives. Understanding its basics—voltage, amperage, and resistance—unlocks efficiency and safety in home usage. Mastery need not involve complex engineering; a grasp of these principles empowers better utilization and appreciation of this remarkable energy. Electricity is the movement of electric current via free electrons along a conductor. Material conductivity depends on electron availability, while key parameters include voltage, amperage, and resistance (measured in ohms).

The pressure that is put on free electrons that cause them to flow is known as electromotive force (EMF). The **volt** is the unit of pressure, i.e., the **volt** is the amount of electromotive force required to push a current of one ampere through a conductor with a resistance of one ohm.

The ampere defines the flow rate of electric current. For instance, when one coulomb (or 6×10^{18} electrons) flows past a given point on a conductor in one second, it is defined as a current of one ampere.

The ohm is the unit of resistance in a conductor. Three things determine the amount of resistance in a conductor: its size, its material, e.g., copper or aluminum, and its temperature. A conductor's resistance increases as its length increases or diameter decreases. The more conductive the materials used, the lower the conductor resistance becomes. Conversely, a temperature rise will generally increase resistance in a conductor.

1.1.11.1 Ohm's Law

Ohm's Law defines the correlation between electric current (I), voltage (V), and resistance (R) in a conductor. Ohm's Law can be expressed as:

$$V = I \times R \quad \text{Equation 1}$$

Where: V = volts, I = amps, R = ohms

Ampacity is the amount of current a conductor can handle before its temperature exceeds accepted limits. These limits are given in the National Electrical Code (NEC), the Canadian Electrical Code and in other engineering documents such as

those published by the Insulated Cable Engineers Association (ICEA). It is important to know that many external factors affect the ampacity of an electrical conductor, and these factors should be taken into consideration before selecting the conductor's size.

1.2 HAZARDS OF ELECTRICITY

The human body is a good conductor of electricity. As a result, electrical current can easily travel through it. There are three main types of electrical hazards: electric shock, electrical burns, and arc blasts (the effect of blasts). Understanding the basics of these hazards is critical in enforcing electrical safety in the workplace.

1.2.1 Electric shock

Electric shock occurs when a body becomes part of an electrical current. Examples of electric shock include:

- A person may come in contact with both conductors in a circuit.
- Touching a live wire and an electrical ground.
- A person may provide a path between an ungrounded conductor and the ground.
- A person may provide a path between the ground and a conducting material that is in contact with an ungrounded conductor.

The severity of electric shock is related to four elements. If the combination of these four elements is exactly right, the shock can be severe or lead to electrocution.

- Amount of current
- Length of time current is present.
- Path of current through the body
- Frequency of the current (Hz)

The amount of the current depends on the potential difference and the resistance. The effects of current on the human body range from a temporary mild tingling sensation to death. Voltage is important only in that it determines how much current will flow through a given body resistance. The current necessary to operate a 10-

watt light bulb is eight to ten times more current than the amount that would kill a person. A pressure of 120 volts is enough to cause a current to flow which is many times greater than that necessary to kill.

1.2.2 Electrical Burns

The most common shock-related injury is an electrical burn. Burns suffered in electrical accidents can be of three types:

- **Electrical Burns** are the result of the electric current flowing in the tissues. These burns may be skin deep or may affect deeper layers such as muscle and bones.
- **Arc Burns** are the result of high temperatures produced by electric arcs or by explosions close to the body (see electrical arc blasts).
- **Thermal Contact Burns** are normally experienced from the skin-contacting hot surfaces of overheated electrical conductors, conduits, or other energized equipment.

Tissue damage is caused by heat generated by the current through the body and is often immediately classified as a third-degree burn. If the energy delivered by the electric shock is high, the body cannot dissipate the heat, and the tissue is burned. Typically, such electrical burns heal slowly.

1.2.3 Electric Arc Blasts

If the current is strong enough, the blast effect that can result from arcing can cause injuries and start fires. The power arc is a discharge of electricity through a combination of ionized air and vaporized conductor material. The conductive material is vaporized by temperatures in an arc which can be as high as 35,000°F.

- Low-energy arcs can cause explosions or blasts in atmospheres containing explosive gases, vapours, or combustible dust.
- High-energy arcs can also damage equipment, causing the metal to fly in all directions.

While no equipment can completely protect electrical workers, several safe practices can help.

- **Limit Exposure.** Reduce the amount of time spent around high-energy equipment.
- **Maintain Distance.** Always stay as far away as possible from high-energy equipment unless there is a specific need.
- **Increase Mass.** Try to keep some type of sturdy material between you and a potential blast.
- **Wear Protective Clothing.** PPE such as flash suits may offer some protection to minimize burns resulting from blasts.
-

1.3 RISK OF ELECTRICITY

What is an electrical risk?

An electrical risk is a risk to a person of death, shock or other injury caused directly or indirectly by electricity. The main hazards associated with these risks are:

- contact with exposed live parts causing electric shock and burns (for example exposed leads or other electrical equipment coming into contact with metal surfaces such as metal flooring or roofs)
- faults which could cause fires.
- fire or explosion where electricity could be the source of ignition in a potentially flammable or explosive atmosphere (for example in a spray paint booth).

Effects of Electrical Current on the Human Body	
Current in milliamperes	Effects
1 or less	No sensation; probably not noticed
1 to 3	Mild sensation not painful
3 to 10	Painful shock
10 to 30	Muscular control could be lost or muscle clamping
30 to 75	Respiratory paralysis
75 mA to 4 amps	Ventricular Fibrillation
Over 4 amps	Tissue begins to burn. Heart muscles clamp and heart stops beating.

Figure 1.3: Effects of Electric current on the Human body

The risk of injury from electricity is strongly linked to where and how it is used. The risks are greatest in harsh conditions, for example:

- outdoors or in wet surroundings – equipment may become wet and may be at greater risk of damage.
- in cramped spaces with earthed metalwork, such as inside a tank or bin – it may be difficult to avoid electrical shock if an electrical fault develops.

Some items of equipment can also involve greater risk than others. Portable electrical equipment is particularly liable for damage including plugs and sockets, electrical connections and the cable itself. Extension leads, particularly those connected to equipment, which is frequently moved, can suffer from similar problems.

1.4 DANGEROUS ACTIVITIES

Electrical hazards, while dangerous, can be prevented when you are aware of the factors that contribute to them. Here is a list of the most common dangerous activities that cause electrical hazards to watch out for:

- **Insufficient insulation** – Over time, electrical insulation can deteriorate due to wear and tear, rodents, or exposure to moisture. This degradation can lead to exposed wires and increase the risk of electric shock or short circuits.
- **Circuit breaker failure** – If the circuit breaker fails to trip during an overload, it loses its protective functioning, further increasing the risk of electrical hazards.
- **Damaged electrical appliances** – Loose connections, frayed wires, or cracked insulation can result in electrical malfunctions.
- **Improper use of extension cords** – Practices like daisy chaining and overloading can cause overheating and ignite electrical fires.
- **Inadequate maintenance** – Failing to regularly inspect electrical systems, ignoring warning signs, or bypassing safety procedures can trigger severe electrical hazards over time.

SUMMARY:

Electricity and electric power cover the basics of how electricity works, the components of an electric circuit, and how electric power is generated, measured, and calculated. It explains the concepts of voltage, current, and resistance, as well as the significance of wattage, amperage, and power ratings in electrical systems. This unit also emphasizes the importance of understanding and efficiently using electrical power for cost-saving and environmental benefits. Additionally, it highlights the potential hazards of electricity, including electric shock, electrical burns, and arc blasts, and the importance of safety practices in electrical work.

Self-Assessment

Q. No.1. Fill in the blanks with the correct answers.

1. Electric experiments were performed in 1800 by _____.
2. Whenever you turn on your light, you are using an_____.
3. _____ is the amount of electrical energy your device needs to work.

4. The most common methods of describing the amount of power produced by electrical energy are wattage and amperage.
5. Wattage is measured in_____.
6. Amperes are measured in_____.

Q. No. 2. Answer the following Questions.

1. What are the components of an Electric Circuit?
2. Describe the Role of Electric Motors and Electric Generators.
3. Elaborate on the difference between Alternative Current (AC) and Direct Current (DC).
4. Define the following:
 - i. Electric Power.
 - ii. Electromotive Force (EMF).
 - iii. Volt.
 - iv. Electric Burns.
 - v. Ohm's law.

Answers of Self-Assessment

Q. No.1. Answers

1. Alessandro Volta
2. Electric circuit
3. load
4. volts
5. Watts
6. Amperage

Q. No.2. Answers

For answers carefully read Unit 1.

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UNIT-2

RISK ASSESSMENT

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INTRODUCTION

Electrical systems are part of everyday life and many industries but also can be a serious danger if not managed properly. Carrying out a proper electrical risk assessment is important to identify the risks, minimize them, and ensure safety. Risk assessment prevents accidents and injuries by evaluating the dangers of electrical equipment, installations, and operations.

Electrical risk assessments ensure individuals working with or around electrical systems are safe and cared for. It finds areas of potential hazard, considers the risks involved, and assists in formulating tactics to mitigate dangers that can arise from electrical installation or operation. This enables any organization to avoid accidents or downtime and ensures all measures are taken in safety regulatory compliance.

In this unit, we are going to explore electrical risk assessments, highlighting the importance of such assessments and the steps needed in conducting a proper electrical hazard evaluation. Learning how to perform a detailed electrical risk assessment can help develop a proactive safety approach, minimize the occurrence of an accident, and thereby sustain a secure working environment.

The definition of a risk assessment is a systematic process of identifying hazards and evaluating any associated risks within a workplace, then implementing reasonable control measures to remove or reduce them.

When completing a risk assessment, it is important to clearly define some keywords:

1. An accident is ‘an unplanned event that results in losses.’
2. A hazard is ‘something that has the potential to cause harm.’
3. A risk is ‘the likelihood and the severity of a negative occurrence (injury, ill-health, damage, loss) resulting from a hazard.’

OBJECTIVES:

1. To understand the principles of risk assessment, risk evaluation and control.
2. To identify and evaluate potential risks in different workplace settings/ environments and their allied risks.
3. To understand and explore methods for mitigating or eliminating identified risks through preparedness.

2.1 REASONS FOR CARRYING OUT AN ELECTRICAL RISK ASSESSMENT

- Electricity can kill or severely injure people and cause property damage. However, you can take simple precautions when working with or near electricity and electrical equipment to significantly reduce the risk of injury to you, your workers, and others around you.
- When one correctly recognizes and manages risks, working near electricity can be quite safe. But electric shock or death could come from insufficient training, inexperience, and a failure to recognize possible threats.
- Being aware of these threats is one of the strongest defenses against them.
- By being aware of the possible dangers connected to electricity, you can take preventative measures to avoid electrical mishaps and fatalities.
- Possessing this information can also help you recognize the warning signals of electrical risks quickly so that you can take appropriate action, thus improving workplace safety.

2.2 FACTORS TO BE CONSIDERED IN CARRYING OUT THE RISK ASSESSMENT

According to the ISO 31000 guideline, you should consider multiple factors during the risk assessment. As the International Organization of Standardization states:

2.2.1 The likelihood of events and consequences

Although the bowtie method is more qualitative at its core, it is also possible to add quantitative data to its different elements. Indeed, there are instances of people combining the LOPA technique with the bowtie methodology to great success.

Layers of protection analysis (LOPA)--A method of analyzing the likelihood (frequency) of a harmful outcome event based on an initiating event frequency and on the probability of failure of a series of independent layers of protection capable of preventing the harmful outcome.

“A 'bowtie' is a diagram that visualizes the risk you are dealing with in just one, easy-to-understand picture. The diagram is shaped like a bowtie, creating a clear differentiation between proactive and reactive risk management.”

In addition, it is also possible to display risk matrices (see Figure 2.1) on consequences or even on the hazard or top event to capture the likelihood of certain events. Likelihood alone, however, is not enough to properly assign the risk.

2.2.2 The nature and magnitude of consequences

Once the likelihood has been verified, it needs to be calculated together with the severity, or magnitude of an event. In this way, the impact of the event on the consequence can be assessed, and as a result, prioritizing which consequence is most dangerous becomes clearer. This will make ALARP analysis easier thus allowing decision makers to make better-informed decisions.

As low as reasonably practicable (ALARP), or as low as reasonably achievable (ALARA), is a principle in the regulation and management of safety-critical and safety-involved systems.

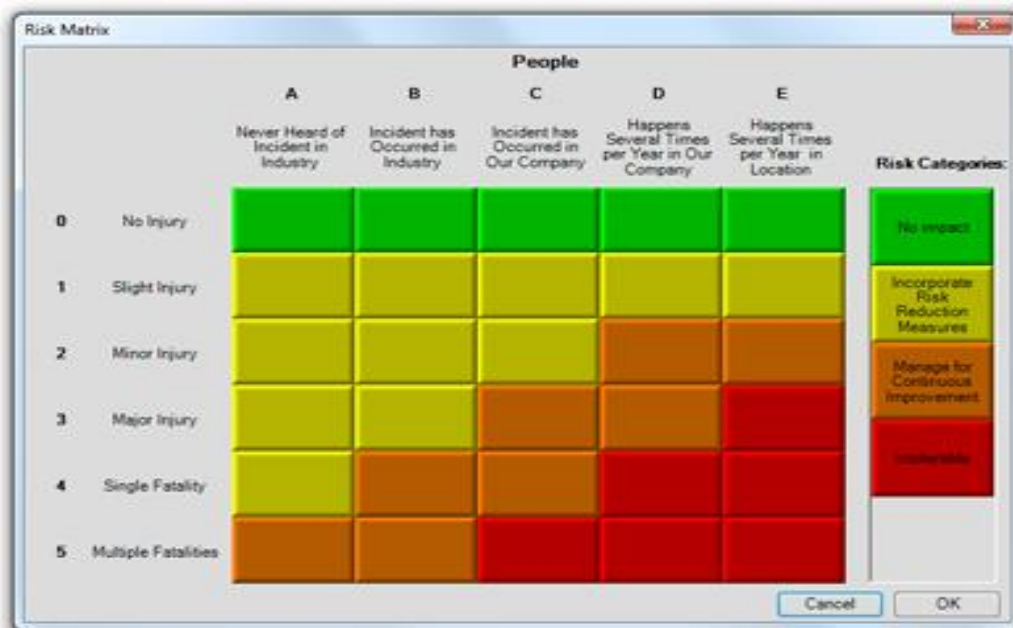


Figure 2.1: A typical risk matrix, ISO Risk evaluation, matrix.

2.2.3 Complexity and Connectivity

ISO 31000 states: “An event can have multiple causes and consequences and can affect multiple objectives”. The bowtie methodology lends itself well to supporting this part of risk analysis. As opposed to risk registers where it is often hard to understand which control, or barrier, is protecting us from which threat. As can be seen in Figure 2.2 below, in the risk register it is hard to see if we have barriers for each threat/consequence line, whereas in the bowtie diagram, it becomes immediately apparent.

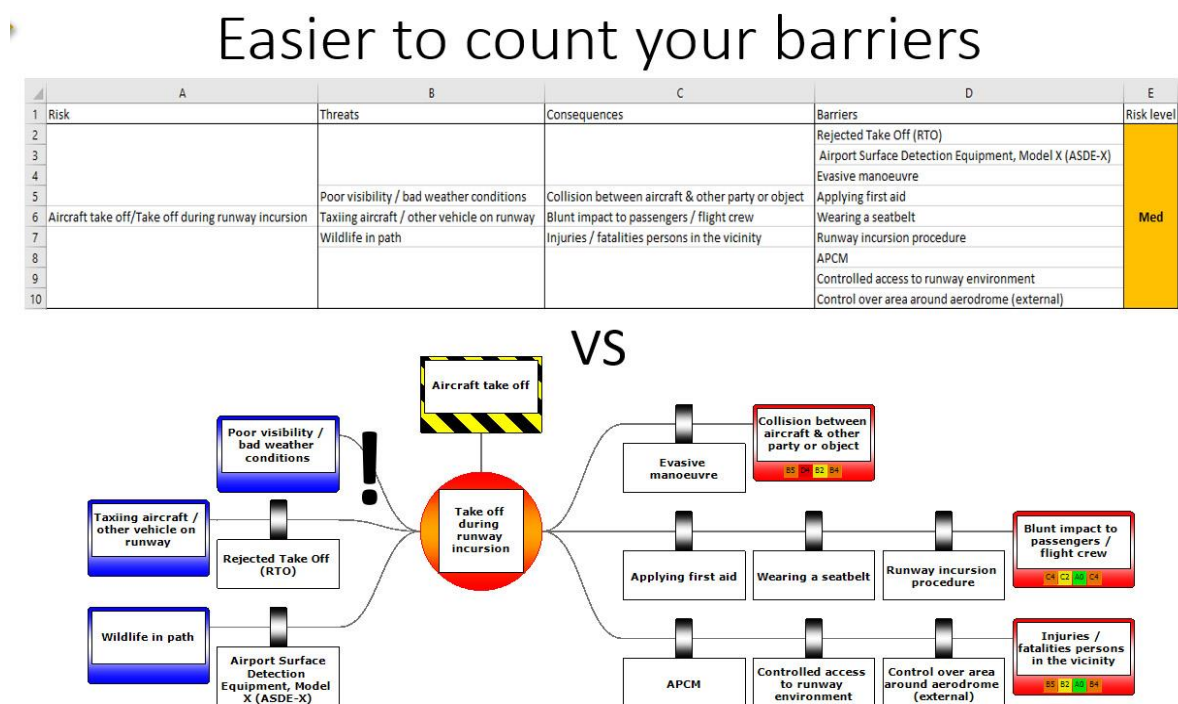


Figure 2.2: A risk register VS a bowtie diagram. Effectiveness bowtie, analysis factors, register bowtie diagram.

2.2.4 Time-related factors and volatility

The time-related factors can be considered a shortcoming of the bowtie methodology as it does not show just how much time a scenario would take to unfold. In addition, the volatility of certain events can sometimes be hard to capture in a bowtie other than by using the risk matrices.

2.2.5 The effectiveness of existing controls

ISO explains that existing controls and their effectiveness and efficiency should also be taken into account when analyzing risk. By displaying the effectiveness of barriers through, e.g., color (see figure 2.3 below), the **final risk that will be** assigned to a scenario in a risk matrix will be easier to understand and thus help to make decisions.

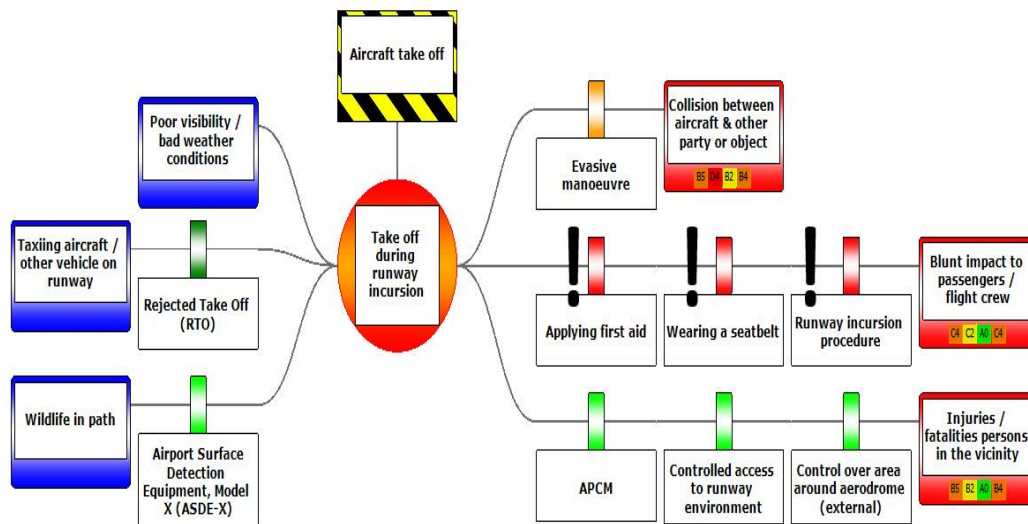


Figure 2.3: Barriers colored according to their effectiveness. Effectiveness bowtie, analysis factors, register bowtie diagram.

2.2.6 Sensitivity and confidence levels

The bowtie methodology is incredibly effective at communicating risks to people in all layers of an organization due to its simplicity. As such, it is important to remember to add doubts and questions to your bowtie diagrams in instances of uncertainty. Simply adding a question mark or some words to the elements in a bowtie can already inform the decision-makers of the uncertainty inherent in the scenario.

2.3 RISK ASSESSMENT CHECKLIST DEVELOPMENT

The HSE (Health and Safety Executive) has recommended a five-step process for completing a risk assessment. This provides a useful checklist to follow to ensure

that the assessment is suitably comprehensive. It involves:

1. Identifying potential hazards
2. Identifying who might be harmed by those hazards.
3. Evaluating risk (severity and likelihood) and establishing suitable precautions
4. Implementing controls and recording your findings
5. Reviewing your assessment and re-assessing if necessary.

2.3.1 Step 1. Identify potential hazards.

It is important to first identify any potential hazards within the workplace that may cause harm to anyone who comes into contact with them. They may not always be obvious so some simple steps you can take to identify hazards are:

- Observation: Walking around your workplace and looking at what activities, tasks, processes, or substances used could harm your employees (or others)
- Looking back over past accidents and ill-health records as they may identify less obvious hazards.
- Checking manufacturers' data sheets, instructions, information, and guidance
- Consulting with employees (and others) who are carrying out the activities, tasks, or processes.
- It may be useful to group hazards into five categories, namely physical, chemical, biological, and psychological.

2.3.2 Step 2. Identify who might be harmed by those hazards.

Next, identify who might be harmed by those potential hazards. It should also be noted how they could be affected, be it through direct contact or indirect contact. It is not necessary to list people by name, but rather by identifying groups.

Some hazards may present a higher risk to certain groups including children, young people, new or expectant mothers, new employees, home workers, and lone workers.

2.3.3 Step 3. Evaluate risk severity and establish precautions.

After identifying any hazards and who might be affected, it is important to evaluate the severity of the risk that may present (should it occur) and establish suitable and effective controls to reduce this level of risk as far as is 'reasonably practicable.' This means that everything possible is done to ensure health and safety considering all relevant factors which are discussed above in this unit.

Assessing the severity of a risk requires an evaluation of the likelihood of an occurrence and how substantial the consequences that it may cause. Some factors affecting this evaluation include the duration and frequency of exposure, number of persons affected, competence of those exposed, the type of equipment and its condition, and availability of first-aid provision and/or emergency support.

2.3.4 Step 4. Implement changes and record your findings.

If a workplace has five or more individuals, significant findings of the risk assessments are required to be kept either electronically or in writing. Recording your findings on a risk assessment form is an easy way to keep track of the risks, and control measures put in place to reduce the identified risk. The form includes:

1. What hazards were found?
2. Person(s) or groups affected.
3. The controls put in place to manage risks and who is monitoring them.
4. Who carried out the assessment?
5. On what date was the assessment done?

It is sensible to ensure the risk assessment is proportionate to the activity or task being carried out and this can often be a straightforward process for generic tasks.

2.3.5 Step 5. Review your assessment and reassess if necessary.

Employers should periodically review the assessment and if necessary, reassess any controls in place. A good guide as to when you may need to review your processes are:

1. After any significant change within the workplace or process in question
2. After an accident or ill-health incident has occurred
3. After near-misses have been reported.

2.4 RISK ANALYSIS

Risk analysis is the process of identifying and analyzing potential issues that could negatively impact key business initiatives or projects. This process is done to help organizations avoid those risks.



Figure 2.4: Risk Analysis | Safety Culture

Risk assessment is just one component of risk analysis. The other components of risk analysis are risk management and risk communication. Risk management is the proactive control and evaluation of risks while risk communication is the exchange of information involving risks. Unlike risk analysis, risk assessment is primarily focused on safety and hazard identification.

A risk assessment forms the backbone of your overall risk management plan. A risk analysis is one piece of the assessment process, where you determine the likelihood and criticality of each risk, and then assign each risk a score based on your findings.

2.4.1 Risk Analysis Methods

Risk analysis is the phase where you will examine each identified risk and assign it a score using one of two types of the scoring system: quantitative or qualitative. These scores help you prioritize your risks, so you know which ones to address first and the best ways to address them.

Qualitative risk analysis rates or scores risk based on the perception of the severity and likelihood of its consequences. Quantitative risk analysis, on the other hand, calculates risk based on available data.

Types of risk analysis associated with qualitative risk analysis are all root cause analysis (RCA) tools except for failure mode and effects analysis, needs assessment, and risk matrix. Furthermore, the most common types of the latter are the 3×3 risk matrix, 4×4 risk matrix, and 5×5 risk matrix.

Likelihood		Very Likely	Likely	Unlikely	Highly Unlikely
Severity	Fatality	High	High	High	Medium
	Major	High	High	Medium	Medium
	Minor	High	Medium	Medium	Low
	Negligible	Medium	Medium	Low	Low



Figure 2.5: Risk Assessment Matrix | Safety Culture

SUMMARY:

A risk assessment is a systematic process to identify hazards and evaluate risks in a specific environment, such as a workplace, and implement control measures to mitigate them. Key terms include accidents, hazards, and risks. Electrical risk assessments are essential due to the potential dangers of electricity. Factors to

consider during a risk assessment are likelihood, consequences, complexity, time-related factors, and control effectiveness. A five-step process for risk assessment involves identifying hazards, determining who may be harmed, evaluating risk severity, implementing controls, and recording findings. Risk analysis is a broader process that includes risk assessment, risk management, and risk communication. Risk analysis methods include qualitative and quantitative scoring systems, with common types being risk matrices like 3x3, 4x4, and 5x5 matrices.

SELF-ASSESSMENT

Q. No.1. Fill in the blanks with the correct answers.

1. _____ is an unplanned event that results in losses.
2. ALARP stands for_____.
3. A_____ is something that has the potential to cause harm.
4. LOPA stands for_____.
5. A_____ form the backbone of your overall risk management plan.

Q. No. 2. Answer the Questions:

1. Define the following:
 - i. Risk.
 - ii. Risk Assessment.
 - iii. Risk Analysis.
 - iv. Bowtie diagram.
 - v. LOPA.
 - vi. ALARP.
2. Elaborate Risk Analysis Methods.

3. Describe the Factor that should be considered while carrying out Risk Assessment.
4. Illustrate the Risk Access checklist Development Procedure.

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UNIT-3

CONTROL MEASURES

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INTRODUCTION

Control measures are essential practices and strategies in the elimination, reduction, or management of risks from electrical systems and operations. It means safety and compliance with applicable standards and regulations. These are established to protect workers, equipment, and the environment against potential hazards that could happen during electrical work or operations. Control measures consider all aspects of the event; these aspects include physical protection for conductors, equipment strength and capability, protective systems and devices, safe systems of work, and emergency procedures.

This unit discusses key control measures important to the production of safe work environments. Properly protecting conductors, satisfactory equipment strength and capacity, practical deployment of protective systems and equipment, and clear safe operating methods coupled with an outlined emergency program are major points in avoiding electrical exposures while ensuring that personnel and other assets remain safe from possible harm.

All these control measures ensure safety in an electrical work environment and should be followed to adhere to the safety standards and respective rules and regulations.

OBJECTIVES

1. To critically analyze and apply various controls designed to minimize electrical hazards to ensure safety and compliance with the requirements of the industry.
2. To study the concepts and methods to protect electrical conductors
3. To examine the strength and capability of electrical conductors in various environments and to ensure durability and long life.
4. To improve preparedness and responsiveness in case of emergencies and hazards.

3.1 INTRODUCTION TO CONTROL MEASURES

A risk assessment is an organization's health and safety responsibility, and control measures are a vital component of this risk assessment process. Control measures are introduced following the identification of hazards and risks within the workplace. The purpose of control measures is to protect individuals in the workplace from the identified risks and hazards, so they are essential.

3.2 PROTECTION OF CONDUCTORS

The cabling and its protection at each level must satisfy several conditions at the same time, to ensure a safe and reliable installation, e.g., it must:

1. Carry the permanent full load current and normal short time over currents.
2. Not causing voltage drops is likely to result in an inferior performance of certain loads, for example: an excessively long acceleration period when starting a motor, etc.

3.3 STRENGTH AND CAPABILITY OF EQUIPMENT

- Electrical equipment shall not be put into use where its strength and capability may be exceeded in such a way that increases risk.
- Strength and capability refer to the ability to withstand thermal, electromagnetic and voltage stresses and other effects of electric current, both in normal use and under faulty conditions.
- Most electrical equipment will only be able to withstand short circuits for brief periods, so any protective devices used should be capable of clearing the fault well within this period.
- Protective conductors and equipment should be able to survive beyond fault clearance times.
- Insulation should be effective under normal and faulty conditions.
- The selection of cables of an appropriate size should take account of the method of installation.

- Rated current carrying capacities can be considerably reduced where cables are grouped, bunched, or insulated.

3.4 PROTECTIVE SYSTEMS AND DEVICES

Moreover, the protective devices (circuit-breakers or fuses) must:

- Protect the cabling and busbars for all levels of overcurrent, up to and including short-circuit currents.
- Ensure protection of people against indirect contact hazards (fault protection), particularly in TN- and IT-earthed systems, where the length of circuits may limit the magnitude of short-circuit currents, thereby delaying automatic disconnection (it may be remembered that TT-earthed installations are necessarily protected at the origin by an RCD, generally rated at 300 mA).
- In the case of motor-starting, or other loads which take a high in-rush current, particularly where frequent starting is concerned (e.g., lift motors, resistance-type spot welding, and so on) the cumulative thermal effects of the overcurrent must be taken into account. Both cables and thermal-type relays are affected.
- At all upstream circuit levels this current corresponds to the kVA to be supplied, which takes into account the diversity and utilization factors, k_s and k_u respectively, as shown in **Figure 3.1**

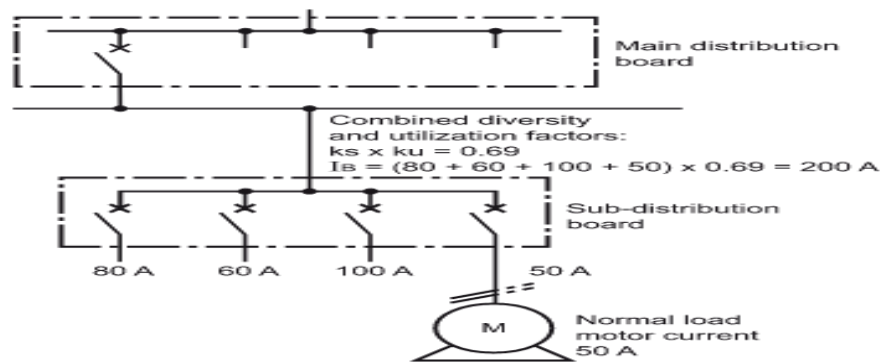


Figure 3.1 Calculation of Maximum

Maximum permissible current:

Current carrying capacity I is the maximum permissible that the cabling for the circuit can carry indefinitely, without reducing its normal life expectancy.

The current depends, for a given cross-sectional area of conductors, on several parameters:

- Constitution of the cable and cableway (Cu or Alu conductors; PVC or EPR etc. insulation; number of active conductors).
- Ambient temperature
- Method of installation
- Influence of neighboring circuits



Figure 3.2 Flow-Chart for the Selection of Cable Size and Protective Device Rating for a Given Circuit

3.4.1 Overcurrent

An overcurrent occurs each time the value of current exceeds the maximum load

current IB for the load concerned. This current must be cut off with a rapidity that depends upon its magnitude if permanent damage to the cabling (and appliance if the overcurrent is due to a defective load component) is to be avoided. Overcurrent of relatively short duration can, however, occur in normal operation; two types of overcurrent are distinguished:

3.4.2 Overloads

These over currents can occur in healthy electric circuits, for example, due to some small, short-duration loads which occasionally occur co-incidentally: motor starting loads, and so on. If either of these conditions persists, however, beyond a given period (depending on protective relay settings or fuse ratings) the circuit will be automatically cut off.

3.4.3 Short-circuit Currents

These currents result from the failure of insulation between live conductors or/and between live conductors and earth (on systems having low-impedance-earthed neutrals) in any combination, viz:

- a. 3 phase short-circuited (and to neutral and/or earth, or not)
- b. 2 phase short-circuited (and to neutral and/or earth, or not)
- c. 1 phase short-circuited to neutral (and/or to earth)

3.4.4 Characteristics of Conductor

- **The type of core:** copper or aluminum.
- **The type of insulation:** which defines the maximum permissible temperature during operation, cross-linked polyethylene cable (XLPE) or Ethylene Propylene Rubber (EPR) for insulation that can withstand 90°C and PVC for insulation that can withstand 70°C.

3.4.5 Wiring Installation System

The standard defines some installation methods which represent the various installation conditions. If several installation methods are used along the length of

the wiring system, the methods for which the thermal dissipation conditions are the least favorable must be chosen.

3.4.6 Ambient Temperature

The ambient temperature has a direct influence on the size of the conductors. The temperature to be taken into account is that of the air around the cables (open-air installation), and that of the ground for buried cables. The basic temperature in the air is given at 30°C and that of the ground at 20°C for all these tables.

3.4.7 Risks of Explosion

In installations where there is a risk of explosion (presence, processing or storage of materials which are explosive or have a low flash point, including the presence of explosive dust), wiring systems must include appropriate mechanical protection and the current-carrying capacity will be subject to a reduction factor.

3.4.8 Parallel conductors

As long as the arrangement of the conductors complies with the grouping rules, the current-carrying capacity of the wiring system can be considered as being equal to the sum of the current-carrying capacities of each conductor to which the correction factors connected with the group of conductors are applied.

3.4.9 Global correction factor

When all the specific correction factors are known, it is possible to determine the global correction factor f , which is equal to the product of all the specific factors.

3.5 USE OF SAFE SYSTEMS OF WORK & EMERGENCY PROCEDURES

3.5.1 Safe Systems of Work

Safe systems of work (SSOW) are legally required procedures to mitigate workplace hazards, offering clear, universal instructions for task completion. Employers conduct risk assessments to identify hazards, then collaborate with experts to design tailored SSOWs. These systems prioritize employee safety by minimizing risks of illness, injury, or fatalities. SSOW language is direct and

universally understandable, focusing on specific task instructions rather than general guidance. They formalize step-by-step procedures to reduce health risks in the workplace. Employers have a legal and moral duty to implement SSOWs wherever significant risks exist. SSOWs are essential tools for creating a safe working environment while acknowledging that total risk elimination may not always be feasible.

3.5.2 Emergency Procedures

All employers are obligated to ensure staff are trained in workplace emergency procedures. This may include what to do in case of a fire, earthquake, or other emergency; identifying locations of emergency exits; and processes to follow to evacuate the building in the case of an emergency. These procedures are site-specific and should be a part of the training for all new employees. In addition, regular drills or reviews of procedures are important to ensure that if an actual emergency occurs, everyone can react accordingly and safely.

Orientation to any new job site, even if temporary, should always include the following information:

- Location of emergency exits.
- Location of first aid supplies or the procedures to call for an attendant.
- Location of fire extinguishers
- Evacuation procedures and muster stations
- Any hazards present on the site.

SUMMARY

This unit emphasizes the crucial role of cabling for carrying full load current, preventing voltage drops, and maintaining fault protection. It discusses the maximum permissible current (I_z) and factors influencing it, such as cable composition, ambient temperature, installation method, neighbouring circuits, and overcurrent.

The conductor characteristics, including core material (copper or aluminium) and insulation type (XLPE, EPR, or PVC), as well as the impact of wiring installation systems and ambient temperature on conductor sizing. It also notes the reduction in current-carrying capacity in installations with explosion risks. Parallel conductors in wiring systems are considered under grouping rules, and the global correction factor is introduced to evaluate the overall impact of specific correction factors on a wiring system's current carrying capacity.

Self-Assessment

Q. No.1. Fill in the blanks with the correct answers.

1. _____ are a vital component within this risk assessment process.
2. _____ are an extremely powerful way to protect your staff from unnecessary risks to their health.
3. Protect cabling and busbars for all levels of overcurrent including currents.
4. The _____ temperature has a direct influence on the size of the conductors.
5. The language _____ needs to be universally understandable, clear, and direct.

Q. No. 2. Answer the following Questions.

1. Elaborate Control Measures and Protection of conductors.
2. Describe the Strength and Capability of Equipment.
3. Illustrate characteristics of Conductors.
4. Write a note on Emergency Procedures.
5. Define the following:
 - i. Over current.
 - ii. Overload.

- iii. Short circuit Currents.
- iv. SSOW

Answers of Self-Assessment

Q. No.1. Answers

- 1. Control Measures
- 2. SSOWs
- 3. Short-Circuit
- 4. Ambient
- 5. SSOW

Q. No.2. Answers

For answers carefully read Unit 3.

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UNIT-4

FIRE INITIATION, CLASSIFICATION AND SPREAD

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INTRODUCTION

Fire is a natural phenomenon, which, if left unchecked, can cause immense danger to life and property. Understanding the principles of fire, its classification, its spread, and common causes of fire incidents in the workplace are basic requirements for preventing fires and properly managing emergencies. A total approach to fire safety begins with an understanding of fundamental combustion principles, knowing the behaviour of fire, identifying common ignition sources, and recognizing the potential consequences of any fire-related incident.

This unit gives an introductory overview of fire, its classification, principles underlying heat transmission and spread of fire, and common causes and consequences of fires in workplaces. Understanding these concepts enables organizations to devise more effective fire prevention strategies and ensure personnel safety, thus minimizing damage to assets and infrastructure.

OBJECTIVES:

1. To understand the basic principles of fire and combustion and how these principles govern the behaviour of fire and the combustion process in different environments.
2. To identify and assess the classifications of fires and apply appropriate firefighting and extinguishing techniques.
3. To explain preventive measures, which are fundamental in managing the risks of fire at the workplace.

4. PRINCIPLE AND CLASSIFICATION OF FIRE

4.1. Principle of Fire

Fire is defined as a rapid oxidation of a fuel producing heat and light. Oxygen, heat, and fuel are frequently referred to as the "fire triangle." Add in the fourth element, the chemical reaction, and you have a fire "tetrahedron." The important thing to remember is to take any of these four things away, and you will not have a fire, or the fire will be extinguished. Essentially, fire extinguishers put out the fire by taking away one or more elements of the fire triangle/tetrahedron. Fire safety, at its most basic, is based upon the principle of keeping fuel sources and ignition sources separate.

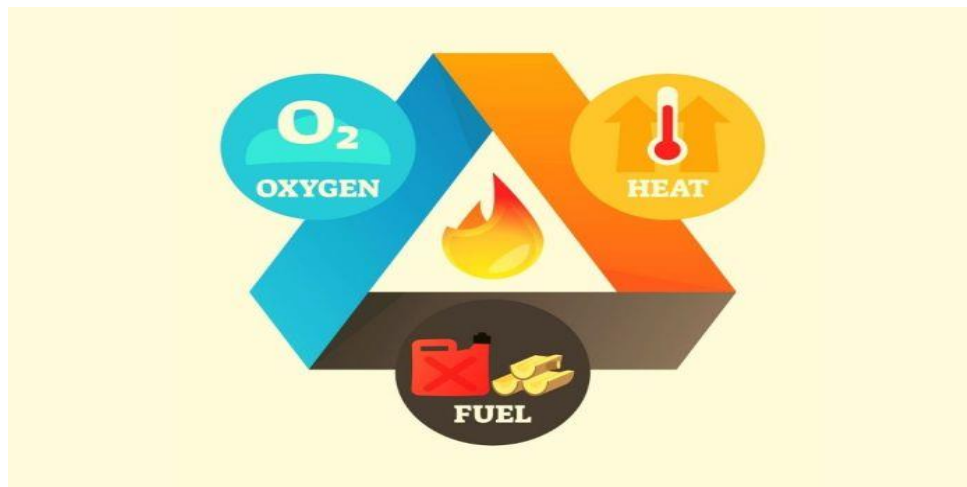


Figure 4.1: Principle of Fire

4.1.1 Fuel

For a fire to start there must be a material to burn and this is referred to as the fuel. Fuel is any kind of combustible material, including paper, oils, wood, gases, fabrics, liquids, plastics, and rubber. The fuel for a fire is usually characterized by its moisture content, size, shape, and quantity and this will determine how easily the fuel will burn and at what temperature.

4.1.2 Heat

In addition to a fuel source, heat must be present for ignition to take place. All flammable

materials give off flammable vapours which, when heat is present, combust. Heat is also responsible for the spread and maintenance of fire as it removes the moisture from nearby fuel, warming the surrounding area and pre-heating fuel in its path, enabling it to travel and develop with greater ease.

4.1.3 Oxygen

As well as fuel and heat, fires also need oxygen to stay alive. Ambient air is made up of approximately 21% oxygen and, as most fires only require at least 16% oxygen to burn, it acts as the oxidizing agent in the chemical reaction. This means that when the fuel burns, it reacts with oxygen to release heat and generate combustion.

4.2 CLASSIFICATION OF FIRE

Class A - fires involving solid materials such as wood, paper, or textiles.

Class B - fires involving flammable liquids such as petrol, diesel, or oils.

Class C - fires involving gases.

Class D - fires involving metals.

Class E - fires involving live electrical apparatus. (Technically 'Class E' does not exist however this is used for convenience here)

Class F - fires involving cooking oils such as in deep-fat fryers.

	 Wood, paper, plastics, soft furnishings etc.	 Flammable liquids, petrol, oil etc.	 Flammable gases, propane, butane, methane etc.	 Metals; aluminium, magnesium, titanium, swarf etc.	 Electrical apparatus, computers, phone chargers etc.	 Cooking oils & fats
AFF FOAM	✓	✓				
WATER	✓					
WET CHEMICAL	✓					✓
CO2		✓			✓	
DRY POWDER	✓	✓	✓		✓	
L2 & M28 POWDER				✓		

Figure 4.2 Classes of Fire

4.3 PRINCIPLES OF HEAT TRANSMISSION AND FIRE SPREAD

4.3.1 Heat Transmission

It is governed by the following factors:

- Direct burning
- Convection
- Conduction and
- Radiation.

4.3.1.1 Convection

It is simply a form of conduction through a fluid mass. It could be due to the thickness of the film on the boundary layer, the temperature difference across boundary layers, the thermal conductivity of fluid in the boundary layer, across a

temperature gradient through a solid, and between two solids initially at different temperatures that are in contact with each other.

Atoms/ molecules at higher temperatures have higher enthalpies. Heat flows from hotter to colder. On a molecular level, larger vibrations of atoms/ molecules pass on their enthalpy or energy to colder areas. Heat is also conducted through stagnant fluids. The rate of conductive heat is proportional to the temperature gradient.

4.3.1.2 Thermal Conductivity

Matter can conduct heat or electrical energy through a given mass. Some materials will conduct energy better than others. Flame radiation strongly influences the rate of burning. The spread of a fire to nearby combustibles often takes place by radiative transfer. The radiant emission from the flames and the hot upper layer of a room determines the time of the flashover. When a room hits a flashover, you as a firefighter in full protective gear, have 5 feet (1.524m) from the doorway to escape to avoid injury or death!! Radiation from a sizable fire can be intense. Occupants can be burned and firefighters' protection from turnout gear may not be enough. If construction materials are overheated, it may compromise the ability of a building to:

- i. Localize a fire to a single compartment
- ii. Remain standing.

Molecules do not need to be in contact with one another for radiative heat. They can travel through a vacuum, pass through any transparent medium (air) or semitransparent medium (water or glass), and travel at the speed of light.

4.3.1.3 Radiation has a spectrum of wavelengths or frequencies

- a. Ranging from X-rays to radio waves
- b. Parts of the spectrum that most affect the transfer of heat in fires:
 - I. Infrared region
 - ii Adjacent part of the visible region

4.3.2 Spread of Fire Basic Principles

- a. Every object at any temperature above absolute zero continually emits radiant energy.
- b. Every object also continually absorbs radiant energy from its surroundings.

- c. The higher the temperature, the greater the rate at which radiant energy is emitted.

Two major sources of radiant heat in a fire:

- Flames
- Hot upper layer forming in a room.

Another radiation source in fire:

- Hot gas molecules in fire effluent (water vapours, carbon dioxide)

4.4 COMMON CAUSES AND CONSEQUENCES OF FIRES IN WORKPLACES

4.4.1 Common Causes of Fires in Workplaces

The most common causes of workplace fires are:

4.4.1.1 Defective Electrical Equipment

Defective electrical equipment can present a significant danger to your staff and your business. Imperfect/loose wiring, faulty/old equipment and overloaded sockets are just a few examples that can cause sparks or overheating and thus fire.

All electrical equipment in your workplace should be well maintained and regularly tested to ensure it functions properly and is not a safety hazard.

4.4.1.2 Flammable/Combustible Materials

Any premises that hold flammable materials like paper, wood and cardboard need to be made sure that they are managed appropriately. If these combustible materials are allowed to build up, they can act as fuel and help any small fire outbreak to escalate.

Appropriate storage, disposal and handling processes of these materials are essential. Ideally, they would be stored off-site and disposed of regularly.

4.4.1.3 Smoking

You should have a dedicated smoking area at least a few meters away from your

building for employees to use. Cigarettes can easily set light to nearby flammable materials like leaves, papers and other items found in rubbish bins, so you must provide your staff with a safe place to dispose of their smoking materials.

4.4.1.4 Negligence & Human Error

Negligence and human error are other major causes of fire in the workplace. This includes improper use of machinery, failing to follow health and safety guidelines, spilling flammable liquids and overusing equipment.

The risk of this can be reduced by making sure staff are fully aware of the workplace guidelines to follow. Regular refresher training should also be provided for staff to remind them of fire risks and how to mitigate them.

4.4.1.5 Faulty Fire Detection Alarms

Although fire detection alarms and systems are not a direct cause of the fire, failure to frequently inspect, maintain and service them can lead to large, uncontrollable fires. By making sure your alarms are working as they should be, you can rest assured that they will notify you in the early stages of a fire, enabling you to tackle and suppress it before it develops into something more serious.

4.4.1.6 Cooking Equipment

Another common place for workplace fires to start is in the staff kitchen. Burning food, leaving cooking equipment unsupervised and the use of combustible materials all present risks, so the correct procedures must be implemented and followed.

4.4.1.7 Untidy & Dirty Workplace

Workplaces that are untidy and cluttered are much more susceptible to fires. Overloaded rubbish bins and poorly ventilated areas, for example, can assist fires to grow. Similarly, forgetting to clean equipment and letting dust build-up can cause machinery to overheat. It is also important that you do not block or cover machinery as this too can cause overheating.

4.4.1.8 Arson

Last on our list of common causes of workplace fires is arson. Industrial and commercial businesses in particular can be targeted by vandals if the building is

often left unattended for a longer time. Installing CCTV cameras and motion sensor lights around the property can act as a deterrent to any lurking criminals.

4.4.2 Consequences of Fire

The consequences of fire can devastate the natural environment, human life, and property. Some of the most significant consequences of fire include:

4.4.2.1 Property Damage

Fires can cause significant damage to property, including buildings, vehicles, and personal belongings. The damage can be particularly severe in the workplace because of valuable equipment, inventory, and important documents.

4.4.2.2 Business Interruption

Business interruption is another significant consequence of the fire. Even if the fire does not cause any property damage, the workplace may need to be closed for some time to be cleaned and repaired, which can result in lost revenue and customers. During this downtime, employees may be unable to work, resulting in a loss of productivity and income for both the employees and the business.

4.4.2.3 Injuries and Fatalities

Workplace fires can also result in injuries and fatalities, with devastating consequences. Burns and smoke inhalation are two of the most common causes of injuries in workplace fires. Victims may require extensive medical treatment, including surgery, skin grafts, and long-term rehabilitation, depending on the severity of the burns.

Smoke inhalation can also cause serious respiratory problems, such as asthma or lung damage, which can have long-term health consequences.

4.4.2.4 Emotional Trauma

Witnessing a fire or experiencing the loss of a coworker in a fire can be emotionally traumatizing, leading to anxiety, depression, and post-traumatic stress disorder (PTSD). Employees who experience a workplace fire may feel shaken and vulnerable and struggle to cope with the event's aftermath. Even if they are not

physically injured, they may experience significant emotional distress, affecting their ability to work and carry out their daily activities.

4.4.2.5 Litigation

Litigation is another potential consequence of workplace fires. If someone is injured or killed in a fire at the workplace, the employer may be held liable and face legal action. This can be costly and time-consuming, damaging the employer's reputation. The legal fees, settlements, and other expenses associated with litigation can add up quickly and have a significant impact on the financial stability of the business.

4.4.2.6 Loss of Productivity

A loss of productivity is another significant consequence of fires. After a fire, employees may need to spend time cleaning up and repairing the damage caused by the fire, which can take away from their regular work duties. Additionally, there may be insurance claims to file and paperwork to complete, which can be time-consuming and further disrupt the workday. The longer the disruption lasts, the greater the impact on productivity, which can have financial consequences for the business.

4.4.2.7 Increased Insurance Premiums

Increased insurance premiums are another potential consequence of workplace fires. After a fire, a business may see an increase in its insurance premiums. This is because insurance companies view businesses that have experienced a fire as higher risk and more likely to file a claim in the future. As a result, insurers may increase the premiums for the business's property and liability insurance policies. These higher premiums can significantly impact the business's bottom line.

4.4.2.8 Damage to Brand Reputation

Damage to brand reputation is another significant consequence of workplace fires, particularly if the incident receives media coverage. A fire at a business can attract significant media attention, damaging the company's brand reputation. Customers may perceive the business as unsafe or unreliable, leading to a loss of trust and decreased revenue. Additionally, negative publicity can spread quickly through

social media, further damaging the business's reputation. The impact on brand reputation can be particularly devastating for small businesses, which may have fewer resources to recover from the damage caused by the fire.

4.4.2.9 Occupational Health and Safety Issues

Occupational health and safety issues are another potential consequence of workplace fires. Fires can release hazardous materials like smoke, chemicals, and other toxic substances. This can pose a serious risk to the health and safety of employees, particularly those who work close to the fire or are responsible for cleaning up the aftermath. In addition, firefighters and other first responders who respond to the fire may also be at risk for exposure to these hazardous materials.

4.4.2.10 Financial Loss

Financial loss is another significant consequence of workplace fires. Repairing or replacing damaged equipment, materials, and property can add up quickly and significantly impact a business's finances. In addition, the business may experience a loss of revenue due to the interruption of normal operations or the need to close temporarily. This can be particularly difficult for small businesses that may not have the financial resources to absorb the costs of a workplace fire. Furthermore, if the business cannot recover from the financial losses caused by the fire, it may have to close permanently.

4.4.2.11 Regulatory Fines and Penalties

Regulatory fines and penalties would be another potential consequence of workplace fires, especially if the fire were caused by violating safety regulations. Regulatory agencies such as OSHA (Occupational Safety and Health Administration) can investigate workplace fires and determine whether any safety regulations were violated. The agency may impose fines and penalties on the business if violations are found. These fines and penalties can be significant and add to the financial losses caused by the fire.

SUMMARY

The principle of fire involves three essential elements: fuel, heat, and oxygen. Fuel can be any combustible material, and its characteristics like moisture content, size,

and quantity determine how easily it burns. Heat is necessary for ignition and also helps the fire spread. Oxygen acts as the oxidizing agent in the chemical reaction, enabling combustion.

Fire is classified into six categories based on the type of fuel involved: Class A (solid materials), Class B (flammable liquids), Class C (gases), Class D (metals), Class E (live electrical apparatus), and Class F (cooking oils).

The spread of fire occurs through direct burning, convection, conduction, and radiation. Understanding these principles and classifications of fire helps in preventing, controlling, and managing fires effectively.

Self-Assessment

Q. No.1. Fill in the blanks with the correct answers.

1. _____ is defined as a rapid oxidation of a fuel producing heat and light.
2. Oxygen, heat, and fuel are frequently referred to as the _____.
3. _____ is any kind of combustible material, including paper, oils, wood, gases, fabrics, liquids, plastics, and rubber.
4. _____ fires involving cooking oils such as in deep-fat fryers.
5. Oxygen acts as _____ in the chemical reaction, enabling combustion.
6. The spread of fire occurs through direct burning, convection, conduction, and _____.

Q. No. 2. Answer the following Questions.

1. Explain the Principle of Fire.
2. Describe the causes of Fire in the Workplace.
3. Illustrate the consequences of Fire in the Workplace.
4. Write the Classification of Fire.

5. Write a note on the Principle of Heat Transmission and Fire Spread.

Answers of Self-Assessment

Q. No.1. Answers

1. Fire
2. Fire Triangle
3. Fuel
4. Class F
5. Oxidizing Agent
6. Radiation

Q. No.2. Answers

For answers carefully read Unit 4.

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UNIT-5

FIRE RISK ASSESSMENT

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INTRODUCTION:

Fire risk assessment is important to ensure that individuals and property are safe from potential hazards caused by fire. A comprehensive fire risk assessment will enable businesses, owners of properties, and other organizations to identify potential dangers and risks and take steps to mitigate them to make safety measures effective. A well-structured fire risk assessment not only helps in compliance with legal requirements but also makes the environment safer for everyone.

In this unit, you are going to acquire knowledge concerning principles for fire safety and how best one would carry out appropriate risk assessment and the creation of safety. This can be important in achieving safety while in the workplace; it fosters a safety culture amongst everyone involved. After reading this unit, you will be much more informed on how to recognize fire hazards, learn the methods of fire prevention, and establish emergency plans that will be effective. Maybe you're getting ready for certification, improving your organization's fire safety, or just learning to increase your knowledge. Either way, this is your resource.

OBJECTIVES:

1. To understand legal, moral, and practical reasons for undertaking a fire risk assessment.
2. To gain knowledge regarding the different factors to be taken into consideration in fire risk assessments: the building design, fire hazards, the people at risk, and fire protection measures.
3. To learn how to make a complete fire risk assessment checklist with all the safety requirements included in it.
4. To recognize the application of the risk matrix for the evaluation of the likelihood and severity of fire hazards and identify appropriate risk control measures.

5.1 REASONS FOR CARRYING OUT A FIRE RISK ASSESSMENT

The aims of the fire risk assessment should be to:

- identify any fire hazards.
- eliminate the hazards or reduce the risk to as low a level as reasonably practicable.
- decide what physical fire precautions and management arrangements are necessary to ensure the safety of people in the building if a fire does start.



Figure 5.1 Fire Risk Assessment

5.2 FACTORS TO BE CONSIDERED IN CARRYING OUT THE RISK ASSESSMENT

This assessment should identify anyone who may be at risk should a fire occur and the inherent risks within the premises. Additionally, the assessment should provide details of all measures introduced to remove or reduce those risks to ensure the safety of anyone in the event of a fire.

These 3 elements should be considered while identifying hazards:

1. **Sources of ignition** – sources of heat that can become hot enough to ignite materials found at the premises.

2. **Source of fuel** – anything that burns.
3. **Sources of oxygen** – which are present in the air around us.

For small, simple premises, it is often the duty holder or the “responsible person” who carries out the fire risk assessment in-house. In such cases, likely, the duty holder’s intimate knowledge of the premises and the activities therein makes them the most appropriate assessor anyway.

However, for larger, more complex premises it may be more appropriate for the duty holder to seek the services of an external consultant: a professional fire risk assessor. Some general practices based in health centers or hospitals may find that the property owner has their facilities, experts or fire advisors who can perform the role.

No matter who carries out the fire risk assessment the employer retains the responsibility for ensuring the adequacy of the assessment.

- If employing a contractor this means making reasonable checks to ensure the contractor is competent to do the job properly.
- To comply with fire safety legislation, primary care organizations have a statutory duty to ensure that risk assessments are conducted that specifically cover fire risks and hazards.
- A fire risk assessment identifies possible hazards as well as the actions needed to ensure the safety of people using the premises.
- Assessments must be kept up to date so that the precautions remain current and adequate. They should be reviewed whenever significant alterations are made to the premises.
- If there are more than five members of staff on the premises, it is a legal requirement for the fire risk assessment findings to be recorded and available for inspection. Staff must be advised of the findings of the assessment.

5.3 RISK ASSESSMENT CHECKLIST DEVELOPMENT



Figure 5.2: Fire Risk Assessment Process

5.3.1 The fire risk assessor

Risk assessments should be carried out by a competent person. The assessor will need to have the following knowledge.

- An understanding of relevant fire safety legislation and the principles of fire safety, including fire development and the behaviour of people around the fire.
- An understanding of fire hazards, fire risks and relevant factors associated with occupants at special risk (e.g., disabled, or elderly patients or visitors who are unfamiliar with the premises, young staff, etc.)

For simple buildings where the fire risk assessor might be an employee of the occupier, it is suggested that a study of suitable guidance documents and the above attributes might be sufficient for fire risk assessing competency. However, for more complex buildings, there will likely be a need for the specific applied knowledge and skills of an appropriately qualified specialist.

5.3.2 Potential fire hazards

The assessment should identify all potential ignition sources on the premises. These

sources may include:

- faulty or misused electrical equipment
- lighting equipment
- naked flames, e.g., candles, gas, or liquid-fueled open-flame equipment
- smoking materials, e.g., cigarettes, matches and lighters.
- electrical, gas or oil-fired heaters (fixed or portable)
- cooking equipment and toasters
- hot surfaces and obstruction of equipment ventilation, e.g., photocopiers
- hot processes, and egg welding by contractors.



Figure 5.3: Fire Hazards Safety Measures Sign

It should also take into account the possibility of arson, deliberate ignition, vandalism, and similar activities. Next, the assessment should identify the sources of fuel that are available, especially any items that will burn easily and are present in sufficient quantity to provide fuel for a fire or cause it to spread to another fuel source. All assessments should consider the production of toxic smoke or gases in a fire situation.

When listing hazards, it is often useful to describe the nature of the harm that they may cause. This helps to focus on the issues that are of importance and to identify the aspect of the hazard that needs to be assessed.

5.3.3 People at risk

The second stage of the assessment is to identify who might be at risk, who is especially at risk and why. To do this, assessors need to identify which parts of the premises people actually use and where staff usually work (either at permanent workstations or at occasional locations). Factors might include:

- the number of people
- their familiarity with the building
- their mobility.

Special consideration should be given to the needs of disabled users of the building. Managers must also consider the potential risk to people such as visitors and visiting contractors, and where these people are likely to be found.

5.3.4 Evaluating the Risks

The next stage is to analyze and evaluate the fire risks. A fire risk is:

- the likelihood that a fire will occur as a result of a fire hazard.
- the extent and severity of the damage (harm potential) which may be caused.

From this, it will be possible to determine what, if any, measures are needed for the control of the hazard and the ensuing risk. The main factors affecting severity are the potential for the development of a fire and the number of people who could be harmed. The potential for ignition is the main factor affecting likelihood.

5.3.5 Harm potential

The harm potential of a hazard will depend on the potential:

- for the development of a fire originating from a hazard
- consequences in terms of life risk and property loss.

To estimate this, the assessor will need to make a judgment of the possible outcomes of the hazard. To assess life risk, existing escape facilities must be considered and thought given to people with disabilities such as impaired mobility, vision, or hearing, and those with learning difficulties.

5.3.6 Recording

Record keeping is an important aspect of the risk assessment process. Full records are also needed in case of legal proceedings.

The record of risk assessment does not need to be complicated. It should be a simple working document to record risk factors and decisions made on the arrangements necessary for control.

Employers should list significant findings, namely:

- significant hazards identified.
- existing control measures in place
- the people who may be affected.

5.3.7 Reviewing the Assessment

The final stage in the risk assessment process is to continuously review it to ensure fire risks continue to be adequately managed. Employers, in addition to routine reviews, practice managers should undertake risk assessment reviews:

- if the number of employees changes significantly
- if there is some reason to suspect the original risk assessment is out of date
- If there is a change in the operation of the business that could affect the safety of workers in a fire.

Regular inspections should be carried out to ensure that fire controls remain adequate and are implemented correctly. Regular checks should also be made of call points, detectors, sounders, fire-fighting equipment, and emergency lighting.

If a fire or “near miss” occurs, this could indicate that the existing assessment may be inadequate, and a re-assessment should be carried out. Any incident should be fully investigated, and the risk assessment reviewed, as necessary.

5.4 RISK ANALYSIS

Risk analysis is the process of identifying and analyzing potential issues that could negatively impact key business initiatives or projects. This process is done to help organizations avoid or mitigate those risks.

The first step in structural analysis of fire risk is to identify and quantify the fire hazards and risks that may affect the structure. This includes analyzing the fire load, the ignition sources, the fire spread, the smoke and toxic gases, the fire duration and intensity, and the occupancy and evacuation factors. You can use various methods and tools for fire hazard and risk assessment, such as fire scenarios, probabilistic methods, fire testing, fire modelling, and performance-based design, as we studied in Unit 2.

SUMMARY:

A fire risk assessment aims to identify hazards, eliminate, or reduce risks, and determine necessary precautions for ensuring safety in case of a fire. For small premises, the duty holder or "responsible person" usually conducts the assessment, while larger complex buildings may require external consultants. The employer is responsible for ensuring the adequacy of the assessment, and if employing a contractor, they must ensure the contractor is competent. Primary care organizations have a legal duty to conduct fire risk assessments. Assessments should be updated and recorded if there are more than five staff members. The assessment should identify potential fire hazards, and people at risk, evaluate risks, and maintain records. Regular reviews and inspections are crucial to ensure fire controls remain adequate.

SELF-ASSESSMENT

Q. No.1. Fill in the blanks with the correct answers.

1. _____ sources of heat that can become hot enough to ignite materials found at the premises.

2. All assessments should consider the production of toxic smoke or gases in a _____ as an important aspect of the risk assessment process.
3. _____ is produced after anything that burns.
4. The final stage in the risk assessment process is to continuously
5. _____ which are present in the air around us.

Q. No. 2. Answer the following Questions.

1. Write down the factors that should be considered while conducting a Risk Assessment.
2. What is Risk Assessment and Risk Analysis?
3. Illustrate Fire Risk Checklist Development Procedure.
4. Describe the importance of Risk Assessment.

Answers of Self-Assessment

Q. No.1. Answers

1. Sources of ignition
2. Fire Situation
3. Record Keeping
4. Source of fuel
5. Review
6. Sources of oxygen

Q. No.2. Answers

For answers carefully read Unit 5.

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UNIT-6

FIRE PREVENTION AND PREVENTION OF FIRE SPREAD

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INTRODUCTION:

Prevention and control of fire risk in the workplace are critical features of creating a safe work environment and productive environment in the workplace. Fires don't only expose employees to possible death or harm but could also be a source of damage to property, machinery, and the community environment. Successful fire safety methods are indispensable for reducing this risk as well as providing compliance with work safety regulations in the place of work. This unit deals with major control measures to reduce the risk of fire in the workplace across various settings. It is a guide to the proper storage of flammable liquids and structural measures that prevent the spreading of fire and smoke in a workplace, as well as the use of electrical equipment in flammable atmospheres. All these can be undertaken and implemented by employers and employees to significantly reduce fire incidents and ensure a safer environment in the workplace. In identifying fire hazards, preventing these hazards, and corrective action at the onset of fire risks, this guide tries to look into all these aspects through detailed discussion. Such an approach in practice people can ensure that their working places create a safety culture so that the devastating effects fires might have on people and their belongings would be reduced.

OBJECTIVES:

1. To understand and evaluate the effectiveness of different control measures based on the nature of the workplace (e.g., residential, industrial, office, healthcare).
2. To explore and learn about the safe storage and handling of flammable liquids, including legal regulations/ standards, appropriate containers, labelling, and storage facilities.
3. To evaluate structural measures for preventing the spread of fire and smoke and ensure the safe use of electrical equipment.

6.1 CONTROL MEASURES TO MINIMIZE THE RISK OF FIRE IN A WORKPLACE

These are the basic ways to Prevent Fire in the Workplace:

6.1.1 Accessible Equipment

Ensure all your fire protection equipment (i.e., fire extinguishers, control panels, etc.) is easily accessible. Also do not block the fire sprinklers or fire alarms with anything, such as dust, debris, or paint. You do not want to hinder the functionality of your equipment.

6.1.2 Proper Disposal

Discard any hazardous waste in a metal container that has a lid. Hazardous waste can include anything from oils to chemicals. Even flammable and combustible materials should be properly disposed of to prevent fire hazards.

6.1.3 Regular Maintenance

Schedule regular maintenance services for all of your fire protection equipment to make sure everything is up to code. It is also smart to make sure any machines in your building are properly maintained to prevent overheating or sparks created from friction.

6.1.4 Safe Storage

If you have chemicals, flammable materials, or other hazardous substances in your building, you will want to make sure they are stored in a safe place. Make sure they are in a dry, secure closet or room that has adequate ventilation. It is also a good idea to keep fire protection equipment for flammable substances near the storage area just in case.

6.1.5 Clean Environment

There are many reasons that you should keep your building neat. One of the main reasons is that when there is a lot of clutter, especially flammable materials such as paper, boxes, etc., then a fire can spread faster. The clutter could also block exits

and make it harder to escape if there is a fire. So, make sure to keep the inside of your building clean and clutter-free.

6.1.6 Precautionary Measures

Fire safety demonstrations can go a long way when it comes to the safety of your building. Make sure to teach building occupants how to react to a fire and how to use a fire extinguisher, along with the other fire protection devices. This can help to prevent a fire from spreading if one does occur in your building.

6.1.7 Building Security

Arson is one of the leading causes of building and structure fires. That is why it is so important to invest in building security. Building occupants should know how to lock up the building behind them and they should know how to report suspicious behavior or people if they see something a little off.

6.1.8 Designated Smoking Area

There should be a designated smoking area that is a safe distance away from the building. Also, make sure to provide ashtrays or other safe options for people to properly extinguish and dispose of their cigarettes. This will help keep your building safe from accidental fires caused by lit cigarettes.

6.1.9 Emergency Plan

Emergency and evacuation plans are important to prevent further damage or issues if there's a fire. It is important that if someone needs to call for help, they know what to do, how to easily find the building address, and what the next steps should be, basic fire safety checklist is shown in **Figure 5.1**. Fire prevention is just as important after a fire has already started because it can reduce the risk of it spreading, which can lead to more damage.

6.1.10 Adhere to OSHA & NFPA Guidelines

Today there are safety standards and regulations put in place to help businesses better prevent fires in the workplace. Both the Occupational Safety and Health Administration (OSHA) and the National Fire Protection Association

(NFPA) provide a set of rules and guidelines to ensure fire protection and safety. Make sure to meet all of their requirements to remain up to code and secure.

The best course of action to ensure fire safety is to prevent fires from starting. Fire prevention can be based on some simple ideas taken from the fire triangle:

- Control fuel sources.
- Control ignition sources.
- Control oxygen sources.

We studied factors that are considered during fire risk assessment in unit 5. In particular, minimize these sources and keep them physically apart.



Figure 6.1: Fire Safety Checklist

6.2 STORAGE OF COMBUSTIBLE AND FLAMMABLE MATERIALS

Combustible materials (such as paper, cardboard, wood, and furnishings), flammable liquids (such as petrol and acetone) and flammable gases (such as butane, propane, and methane) are all potential fuels and should be stored, handled,

transported, and used with appropriate care if the fire risk that they represent is to be controlled.

The best option is to eliminate combustible and flammable materials and substances from the workplace. This might be done, for example, by disposing of old stocks of materials and substances that are no longer needed.

Alternatively, it may be possible to substitute one potential fuel source for another that presents less of a fire risk. For example, a petrol-powered generator might be changed to a diesel-powered one, eliminating the need to store and handle petrol. Since petrol is a highly flammable liquid (i.e., easily ignited at lower ambient air temperatures) but diesel is not (i.e., not easy to ignite at ambient air temperatures) there is a considerable reduction in fire risk.

If combustible and flammable materials cannot be eliminated or substituted, then the quantities of these materials present in the workplace should be minimized. This requires good stock control, housekeeping, and waste management. For example, cardboard is used extensively by many manufacturing companies as a packaging material. It will be stored in bulk in a warehouse. Minimizing the stocks of cardboard reduces the fire risk in the warehouse.

6.2.1 Storage of Flammable Liquids

For the combustible and flammable liquids/ materials that remain arrangements must be made for safe use and storage.

For example, if liquefied petroleum gas (LPG) is present in a workplace the following arrangements should be made:

- Bottles (cylinders) should be stored outside.
- The storage area should be fenced with a secure, lockable gate.
- Warning signs should be displayed.
- Ignition sources should be eliminated from the area.
- Bottles should be kept upright and chained together.
- The storage area should be separate from other buildings.

- Empty and full bottles should be kept separate.
- Oxygen bottles should not be stored with LPG.
- Only those bottles required should be removed from the storage area and should be returned after use.

6.2.2 Control of Ignition Sources

Poor control of potential ignition sources is a common cause of workplace fires.

- **Electrical equipment** should be routinely inspected and tested to ensure that it is safe. This will prevent faults from developing that might cause sparks or overheating. Both portable appliances and fixed installations should be checked.
- **Hot work** should be controlled with a permit-to-work system unless it is carried out in a purpose-built area, such as a welding bay in a workshop.
- **Smoking** should be controlled in the workplace. It is illegal to smoke in indoor workplaces in some countries. Even when it is not illegal, smoking can be controlled by company policies that ban or restrict it. In all cases, attention must be given to the safe disposal of smoking materials.
- **Cooking** and heating appliances should be used carefully, and their use closely supervised. In particular, they should not be left unattended.
- **Mechanical heat** (such as friction from machinery and bearings) can be controlled by routine maintenance.
- **Deliberate ignition** can be controlled by making good security arrangements for the workplace. A perimeter fence, security staff at entrances, CCTV, security lighting, etc. can help.

6.2.3 Systems of Work

Systems of work must be designed to minimize fire risk. The degree to which this is done and the exact procedures implemented should be decided through the risk assessment process.

An example of a safe system of work applied to fire safety is the use of a permit-to-work system to control hot work (where naked flames or a significant ignition source will be created).

6.2.3.1 Typical precautions for control of hot work:

- Combustible and flammable materials are removed from the work area.
- Items that cannot be removed are covered with fire-retardant blankets.
- The floor is swept clean.
- Any wooden floor is damped down.
- A suitable fire extinguisher is at hand.
- A “firewatcher” is present in the area while the work is carried out.
- The work area is visited routinely after work has finished checking the area for smoldering.

6.2.4 Good Housekeeping

Good housekeeping is fundamental to fire safety and is about keeping the workplace:

- Waste-free, by removing waste regularly (e.g., emptying full litter bins) so that it does not build up and increase the fire risk as a potential fuel source.
- Tidy, so that combustible and flammable materials are returned to safe storage after use (e.g., solvents returned to the solvent store).
- Well-ordered, so that fuel and ignition sources are kept separate (e.g., ensuring fan heaters are not obstructed).

Pedestrian routes should also be kept clear (e.g., with no obstructions by the fire escape door) so that they can be used in the event of a fire evacuation.

6.3 STRUCTURAL MEASURES FOR PREVENTING THE SPREAD OF FIRE AND SMOKE

The term ‘**structural measures**’ defines the features of a building that are

constructed to serve as part of a fire protection strategy. If a fire were to occur, it helps to preserve a building's structural integrity for as long as possible.

The main purpose of structural fire protection is to prevent fire and smoke from spreading throughout the building. This helps to contain the damage and ensure there is an ample window for the building's inhabitants to be safely evacuated. A building must maintain its structural stability in the event of a fire:

- A building less than 5 meters tall must remain stable for 30 minutes.
- A building between 6 and 18 meters tall must remain stable for 60 minutes.
- A building between 19 and 30 meters tall must remain stable for 90 minutes.

Below are some examples of structural measures (commonly used in a passive fire protection strategy) that can stop a building from being fully consumed by fire. When implemented correctly, these measures can save lives and reduce financial losses.

6.3.1 Intumescent Coatings

In the event of a fire, steel will lose its load-bearing properties once it reaches a certain temperature (this can vary between 350° and 750°). Therefore, steel structures must be insulated using intumescent paint. This increases the amount of time before the steel collapses, giving firefighters more time to evacuate a building.

When exposed to temperatures of up to 250°C, multiple chemical components inside the intumescent coating will react. This causes the coating to increase in density, creating a fireproof layer to protect the steel. These intumescent coatings can be applied in a variety of ways, from thin filming coatings to spray-applied paint.

Intumescent coatings are easy to apply both on and off-site. They are also suitable for not only steel but also concrete, timber, and composite elements. As well as this, applying an intumescent coating does not affect the material's mechanical properties. This means that the coating is essentially 'neutral' unless exposed to extreme temperatures. This makes intumescent coatings both an efficient and effective fire protection measure.

6.3.2 Compartmentation

Fire compartmentation involves dividing a building into a series of ‘cells. These cells are then separated using fire-resistant materials and structures. Fire can quickly engulf a building due in part to the ‘chimney effect.’ This is when the airflow between floors and rooms ‘pushes’ flames throughout a structure. Compartmentation reduces this effect, containing the flames and smoke in a specific cell.

There are multiple ways to compartmentalize a building, such as firewalls, doors, and cavity barriers. Cavity barriers inhibit the spread of smoke through open spaces on roofs and between floors. These barriers can be made from a variety of materials, such as concrete, gypsum or masonry.

There is no doubt that in principle, compartmentation is an effective way to hinder the spread of fire. However, there are times when compartments can be breached due to building maintenance. This leads to our next structural fire protection measure.

6.3.3 Firestopping

Sometimes when plumbers, electricians, and contractors work on a building, they can inadvertently compromise structural fire protection measures. Say an electrician drills holes and runs wires through a firewall. No matter how small this hole may be, the wall no longer offers effective fire protection. Fire can penetrate the smallest gaps and ignite almost anything that lies in its path. Therefore, these gaps must be filled as quickly as possible, and by qualified fire-stopping contractors. This process is called ‘fireproofing.’

Successful fireproofing requires the use of specific fire-resistant materials. Any breaches in fire compartments must be filled using an intumescent sealant. When exposed to high temperatures. This fills any gaps and prevents the passage of smoke and flames. Any openings between compartments, such as doors, windows, joints, pipes, and ducts, must be fireproofed. It is vital that in the event of a fire, there is no opportunity for fire to break through a compartment.

Construction professionals must realize that it takes more than investing in structural measures. Firstly, these measures must be implemented in compliance with industry regulations. Secondly, they must be reviewed regularly, with any breaches or material degradation swiftly rectified.

6.4 USE OF ELECTRICAL EQUIPMENT IN FLAMMABLE ATMOSPHERE

“Electrical equipment can produce arcs or sparks and can get hot, electrical equipment is used in process plants where there can be gases, vapours, dust, or fibres which are combustible or flammable”

The fact of the matter is that we do have some! But the reason we do not have lots and lots of electrically initiated fires and explosions on process plants is because we apply methods to systematically **IDENTIFY** where our flammable atmospheres can occur, we **CLASSIFY** the particular hazards that exist in each **HAZARDOUS LOCATION**, and we ensure we select and install electrical equipment that is **designed for safe use** in each.

It should be of no surprise that electrical equipment has the potential to cause fire, flash fire, and explosion. Most electrical equipment, mainly powered, or battery-powered, can produce electrical sparks and heat. Look at the spark from a light switch when activated in a darkened room or feel the heat from the motor on your home vacuum cleaner after normal operation and you will know what we mean. Even the batteries in unrated, portable electronic devices can cause fire and explosions. Furthermore, some electrical equipment can fail, leading to mechanical or electrostatic sparking or heating, and others can allow material ingress/contamination leading to malfunction, short circuits and other dangerous fault conditions.

6.4.1 Intrinsically safe electrical equipment

It will limit the energy present in equipment such that it is insufficient to ignite a particular hazardous atmosphere under any conditions. In practice that means operating with both low power and ensuring any energy stored within is small.

6.4.2 Explosion-proof (or flame-proof) equipment

It is strong and is enclosed in some way such that it will not ignite any local hazardous atmosphere, even if an explosion were to occur inside the equipment. There are some methods used by instrumentation and equipment manufacturers to ensure their equipment is flame/ explosion-proof. These include:

- Sealing to prevent entry of flammable gas,
- Pressurization with clean air or inert gas to displace any hazardous substances from within,
- Encapsulation in resin or immersion in oil,
- Temperature of external surfaces to be known and limited to avoid self-ignition of gases, vapours, or dust, even if dust deposits build up.

SUMMARY

Preventing fires in the workplace involves accessible fire equipment, proper disposal of hazardous waste, regular maintenance of fire protection devices, safe storage of chemicals, a clean environment, employee training, building security, designated smoking areas, emergency plans, adherence to safety guidelines, controlling combustible materials, managing ignition sources, and implementing structural fire protection measures.

SELF-ASSESSMENT

Q. No.1. Fill in the blanks with the correct answers.

1. Systems of work must be designed to minimize_____.
2. _____equipment should be routinely inspected and tested to ensure that it is safe.
3. The _____area should be fenced with a secure, lockable gate.
4. Do not block the _____with anything, such as dust, debris, or paint.

Q. No. 2. Answer the following Questions.

1. Illustrate the Use of electrical equipment in the flammable atmosphere.
2. Write a detailed note on the following:
 - i. Storage of Flammable Liquid.
 - ii. Control Measures to prevent fire in the Workplace.
 - iii. Structural Measures to prevent the spread of Fire and Smoke.

Answers of Self-Assessment

Q. No.1. Answers

1. Fire Risk
2. Electrical
3. Storage
4. Fire Sprinklers

Q. No.2. Answers

For answers carefully read Unit 6.

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UNIT-7

FIRE ALARM SYSTEM AND FIRE- FIGHTING ARRANGEMENTS

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INTRODUCTION:

Through this unit, students would learn the essential fire safety elements that make up complete effective fire prevention, response, and recovery strategies. They will be able to implement best practices for fire safety in various environments, as the knowledge gained will protect both people and property in cases of fire emergencies. **Fire detection and alarm systems** are designed to recognize the occurrence of fire as early as possible, providing enough time for people inside a building to evacuate it and also time for emergency services to be mobilized and respond accordingly. The subsequent section explores different kinds of fire detection systems which are smoke detectors, heat detectors, and flame detectors in addition to alarm systems alerting people to act instantaneously. **Portable firefighting equipment** refers to firefighting equipment like hoses, fire blankets, and extinguishers that an individual uses to fight a minor fire before it worsens. It explains the importance of selection, servicing, and proper use of portable fighting tools so that in a fire emergency, everyone acts together in response. **Access for fire evacuation** discusses the fact that access routes to a building should be free of obstruction and easily accessible both for the occupants and emergency forces. The design of safe evacuation paths, the importance of proper signage, and legal requirements should ensure that the exit remains accessible under all conditions, especially during a fire. **Rescue services** are also an important component of fire safety, being often the first responders in cases of fire. This section explores the role of fire rescue teams, how on-site personnel coordinate with emergency services, and how effective planning supports the speedy deployment of rescue operations in life-threatening situations.

OBJECTIVES:

1. To understand the importance and function of fire detection and alarm systems.
2. To learn about the types of fire detection and alarm systems (e.g., smoke detectors, heat detectors, manual call points).
3. To identify various types of portable fire extinguishers (water, foam, CO₂, dry powder) and their specific uses based on different fire classes.
4. To examine the role of rescue services in evacuation planning and collaboration with emergency services.

7.1 FIRE DETECTION AND ALARM SYSTEMS

The risk assessment must consider the fire detection and alarm systems currently in place, if any, and determine whether they are adequate. Occupants in buildings must be given a clear warning of a fire. Premises must, therefore, be equipped with appropriate fire detectors and alarms where the risk assessment indicates that this is necessary.

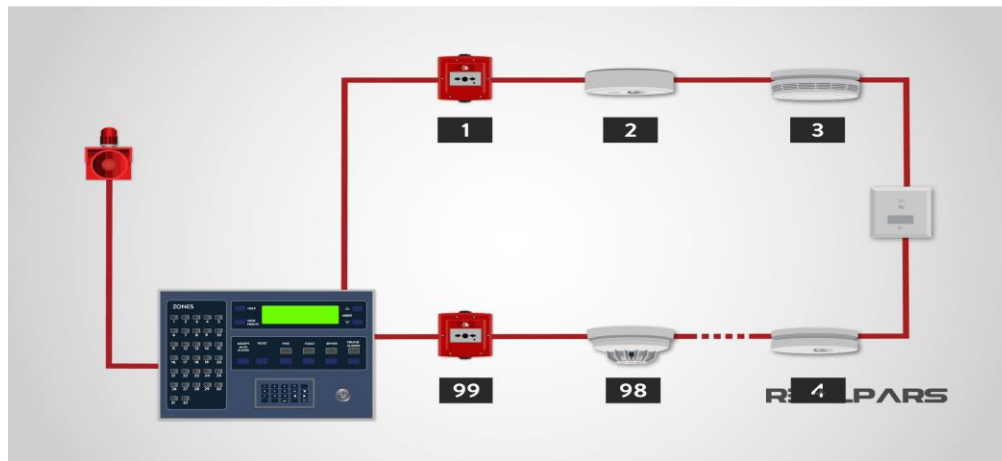


Figure 7.1: Fire Detection and Alarm

It is not necessarily compulsory for every office building to have automatic fire detection, for instance, and much will depend on the size, layout, design, and use. In a small, single-story building with low risk, smoke alarms and a manually operated alarm would be adequate. In larger buildings, a more sophisticated automatic detection and alarm system will be required, particularly where the premises contain places where a fire might start unobserved, such as stores or voids. Wherever necessary, expert fire safety advice should be obtained.

Producers and suppliers of fire alarm systems usually provide advice on the required type of system appropriate to the degree of risk and type of premises. It is important to decide if the main purpose of the detection and alarm system is to protect the safety of occupants or to minimize property damage. The system is classified as follows.

- **Category 1** systems are intended for the protection of property and incorporate automatic fire detection throughout the protected building.
- **Category 2** systems are also installed for the protection of the building but incorporate automatic fire detection only in defined parts of the building.
- **Category 3** systems are intended for the protection of life and incorporate automatic fire detection throughout the protected building.
- **Category 4** systems are also intended for the protection of life but include automatic detection only in defined parts of the building, which include those parts in which type 5 systems would require detectors to be installed.
- **Category 5** systems are installed only for the protection of escape routes.
- **Category 6** systems are also installed only for the protection of escape routes and are equivalent to Category 4 systems.
- **Category 7** systems are installed to protect areas and/ or locations of detectors and are designed to satisfy a specific fire safety objective other than the objectives of other systems.
- **Category 8** systems do not incorporate automatic fire detectors but are manual fire alarm systems.

7.1.1 Systems can also be divided into the following types:

- **Conventional fire alarm systems** — where detectors work like a switch — when they are activated, they switch on the panel, which in turn will switch on the bells or sounders.
- **Addressable fire alarm systems** — which rely on modern technology to individually address each device in the system — when a device is activated, the panel may indicate both the zone and the actual device location.

Difference Between Conventional & Addressable Fire Alarm

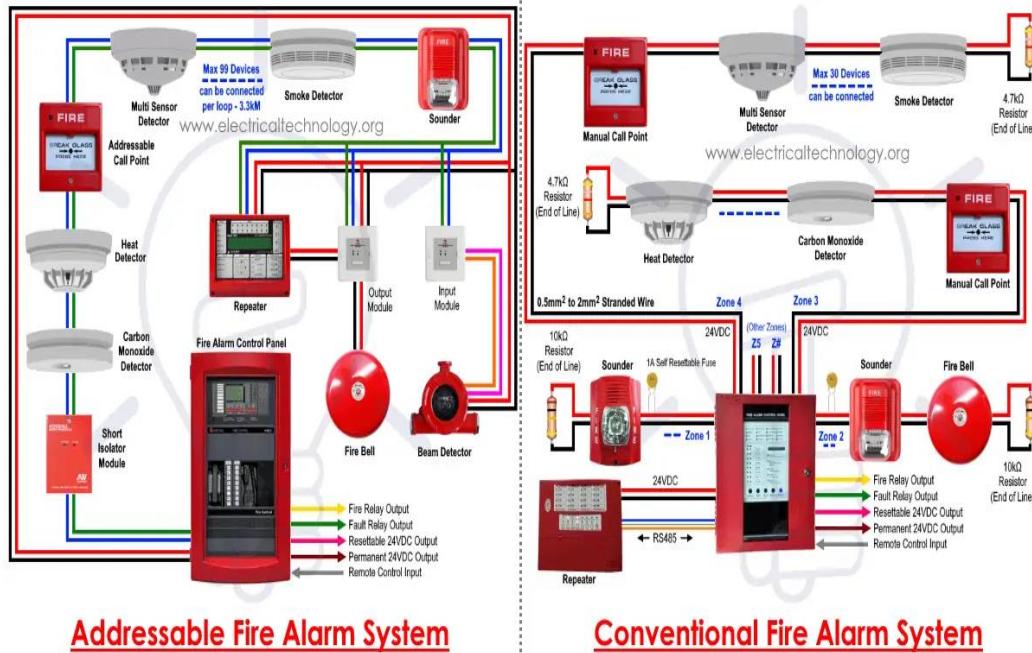


Figure 7.2: Types of Fire Alarm

7.1.2 Types of Detectors

Detectors, or sensors, come in many shapes and sizes and are designed to pick up trace evidence of a fire at the earliest opportunity. Some of the main types are as follows.

- Heat detectors record the rate of rise in the temperature in the vicinity. Any recorded change triggers the fire alarm.
- Smoke detectors detect a fire that produces a lot of smoke or soot but little real heat. There are two categories of smoke detectors:
 - optical types
 - ionization types.

- Flame detectors detect the amount of light produced by the fire. If this type of detector is chosen, some adjustment is needed to eliminate extraneous light sources.
- Carbon monoxide detectors are good for premises with sleeping accommodation. Carbon monoxide is normally an early product of a fire, i.e., some 25 minutes before heat, smoke or flames can be detected.

7.1.3 False Alarms and Coincidence Connection

To avoid false alarms, many fire authorities will only respond if the fire detection system shows two activations, preferably from different types of sensors. This verification requirement is often referred to as a coincidence connection.

7.1.4 Manual Call Points

Manually operated systems are only effective when people are present to raise the alarm. Electrical systems with manual call points are designed so that they can be operated by people from points throughout the building. They have a breakable or fragile element which breaks or appears to break, during the operation of the device. Most employers combine automatic sensors with manual call points as a means of raising the alarm.

Manual call points must meet the following requirements.

- Operation must require only a single action which should be irreversible by the operator.
- No person should need to travel more than 30 metres to raise the alarm.
- Alarm points should be at a height of 1.4 metres above the floor.
- Call points should be sited on exit routes, staircase landings and at fire exits.
- Call points should be sited at “zone junctions” and specific hazards.

7.1.5 Sounders, Sirens, and Other Alarms

Any fire detection system must produce a clear, audible warning such as a bell, siren, or voice message. The employer must ensure it is obvious that the sound is of a fire alarm and nothing else.

The location of the audible warning devices depends on the nature of the workplace, but there should be at least one sounder in each fire compartment. The minimum sound level for such a device is 65dB (decibels), e.g., at least 5dB above the ambient noise level in that workplace.

7.1.6 Care and Maintenance

It is recommended that the user carries out certain checks on a daily, weekly, and monthly basis, as described below.

- **Daily.**
 - Faults recorded on the panel should be recorded and received attention.
 - Any unmonitored remote link should be tested.
- **Weekly.**
 - At least one call point or end-of-line test switch should be operated to test the system, and all zones should be tested over 13 weeks.
 - Check and top up batteries.
 - Check and top the fuel, oil, and coolant levels of any standby generator, as necessary.
- **Monthly.**
 - Start-up emergency generator.
 - The entire installation should be subjected to a quarterly inspection and test by a competent person.
 - Routine safety inspections should ensure that access to manual call points is not obstructed.

The system must be maintained regularly to always ensure maximum efficiency and minimum inconvenience.

7.1.7 Fire Suppression and Sprinkler Systems

Some premises may have fire suppression systems linked to their automated warning systems. The requirement for such systems may be indicated by fire risk assessment and may be required by law in certain buildings in Scotland and Wales.

Sprinkler systems are the most common automatic fire suppression systems. They work through sprinklers placed in ceilings, which operate whenever an automated sensor in a room detects heat.



Figure 7.3: Fire Suppression and Sprinkler Systems

7.2 PORTABLE FIRE-FIGHTING EQUIPMENT

The category of portable firefighting equipment includes fire blankets and portable extinguishers, which due to their mobility enable their use directly in the place of danger. They are particularly useful in the first phase of a fire when it is possible to immediately activate the extinguisher and move with it. Employers must ensure that suitable and sufficient portable fire-fighting equipment is provided on the premises, as indicated in the risk assessment.



Figure 7.4: Portable Emergency Fire-fighting Equipment

7.2.1 Fire Extinguishers

Fire extinguishers should be situated appropriately throughout the premises.

Different types of extinguishers exist, each designed to cope with a particular type of fire. All extinguishers are red, but they are distinguished from each other by the color of their label. Common types are:

- Water — red labels for paper, wood, textile, or fabric fires, not suitable for liquid or electrical fires
- Carbon dioxide — black label — ideal for electrical fires
- Dry powder — blue label — multi-use, best for liquid fires
- Foam — cream label — multi-use, more versatile than water.

7.2.2 Fire Blankets

Fire blankets are made of fire-resistant materials. They are particularly useful in kitchens for smothering cooking fires or for wrapping around a person whose clothing is on fire.



Figure 7.5: Fire Blanket

7.3 ACCESS TO THE FIRE EVACUATION

Emergency access is critical during an emergency such as a fire, chemical release, or explosion. During a fire, timing and quick response are essential to save lives and property. Effective emergency access ensures that fire trucks can reach a building in time to extinguish the fire. Unobstructed emergency egress ensures that building occupants can exit a building to safety. These definitions help clarify the concept of emergency access and egress:

7.3.1 Emergency Access:

Permanent facilities and equipment remain available and unobstructed at all times to ensure effective fire detection, evacuation, suppression, and response.

7.3.2 Emergency Egress:

A continuous and unobstructed way to travel from any point in a public way. A means of egress may include horizontal and vertical travel routes, including intervening rooms, doors, hallways, corridors, passageways, balconies, ramps, stairs, enclosures, lobbies, courts, and yards.

IMPORTANT: Each location within a building must have a clear means of egress to the outside.

7.3.3 Corridors, Stairways and Exits

An exit corridor and/or stairway is a pedestrian pathway that allows direct access to the outside of a building and/or allows access to a building entrance and subsequent pathways to the outside of a building (i.e., an exit corridor is the quickest, easiest, and most direct pathway for leaving a building.) Because exit corridors or passageways are the primary means of egress during an emergency, employees must follow the safety guidelines outlined in this section.

IMPORTANT: There must be at least 44 inches clear width of unobstructed, clutter-free space in all corridors, stairways and exits.

Follow these guidelines to promote safe evacuation in corridors, stairways and exits:

- Keep all means of egress clean, clutter-free, and unobstructed.
- Do not place hazardous materials or equipment in areas that are used for evacuation.
- Do not use corridors or stairways for storage or office/laboratory operations. Corridors may not be used as an extension of the office or laboratory.

7.3.4 Fire Lanes

A fire lane is an area designated for emergency personnel only. It allows them to gain access to building and/or fire protection systems. Although most fire lanes on campus are marked, not all fire lanes are easy to distinguish.



Figure 7.6: Fire Lane

IMPORTANT: Do not park in fire lanes or within 15 feet of fire hydrants and other fire equipment.

7.3.5 Fire Doors

A fire door serves as a barrier to limit the spread of fire and restrict the movement of smoke. Unless they are held open by the automatic systems, fire doors should remain closed at all times. Do not tamper with fire doors or block them with equipment, potted plants, furniture, etc.

Fire doors are normally located in stairwells, corridors and other areas required by the Fire Code. The door, doorframe, locking mechanism and closure are rated between 20 minutes and three hours. A fire door rating indicates how long the door assembly can withstand heat and a water hose stream.

Always keep fire doors closed. If it is necessary to keep a fire door open, have a special automatic closure installed. This closure will connect the fire door to the building's fire alarm system and will automatically close the door if the alarm system is activated.



Figure 7.7: Fire Door

IMPORTANT: Know which doors are fire doors and keep them closed to protect building occupants and exit paths from fire and smoke. Never block a fire door with a non-approved closure device such as a doorstop, block of wood, or potted plant. For fire doors with approved closure devices, make sure that nothing around the door can impede the closure.

7.4 RESCUE SERVICES

Rescue services are organizations that ensure public safety, security, and health by addressing and resolving different emergencies. Many of these agencies engage in community awareness and prevention programs to help the public avoid, detect, and report emergencies effectively. Rescue emergency services are often considered first responders, and typically have dedicated emergency vehicles.

Rescue 1122 is an emergency service that serves Punjab Province, KPK Province, Balochistan Province, Sindh Province, Gilgit-Baltistan Province and Azad Kashmir

Republic in Pakistan. The service is accessed by calling 1122 from any phone in Pakistan.



Figure 7.7: Rescue Service

The Punjab Emergency Service (Rescue 1122) is the leading emergency humanitarian service in Pakistan with infrastructure in all 36 districts of Punjab and is providing technical assistance to other provinces. Rescue 1122 was established under the Punjab Emergency Service Act 2006 for the professional management of emergencies such as road traffic crashes, medical emergencies, building collapses, fire, hazardous material incidents, explosions, flood & water rescue, and animal rescue etc. Their service is invaluable, their empathy is inspirational, and their slogan is humanity.

SUMMARY

Fire detection and alarm systems should be tailored to risk levels and premise types, with categories like property protection, life protection, and escape route protection. These systems can be conventional or addressable. Detectors, manual call points, and alarms should be strategically placed and regularly checked. Fire suppression systems, extinguishers, and blankets may be required based on risk assessments. Prevention measures include managing electrical risks and ensuring clear escape plans for all, including disabled individuals.

SELF-ASSESSMENT

Q. No.1. Fill in the blanks with the correct answers.

1. Fire blankets are made of _____ materials.
2. Smoke detectors detect a _____ that produces a lot of smoke or soot but little real heat.
3. Portable _____ equipment includes fire blankets and portable extinguishers.
4. Sprinkler systems are the most common _____ fire suppression systems.
5. _____ detectors record the rate of rise in the temperature in the vicinity.

Q. No. 2. Answer the following Questions.

1. Describe the difference between Conventional and addressable fire alarms.
2. Write down the types of fire detectors.
3. Define Emergency Access and Egress.
4. Write a note on the following:
 - i. Fire Detector and Fire Alarm.
 - ii. Fire Suppression and Sprinkler System.
 - iii. Fire Extinguisher and Blanket.
 - iv. Fire Lane and Door.

Answers of Self-Assessment

Q. No.1. Answers

1. Fire-resistant
2. Fire

3. Firefighting
4. Automatic
5. Heat

Q. No.2. Answers

For answers carefully read Unit 7.

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UNIT-8

EVACUATION OF A WORKPLACE

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INTRODUCTION

Effective response to emergencies has always been an integral component of safety management in the workplace, public buildings, or even residential places. This unit discusses the core aspects of emergency evacuation including means of escape, emergency evacuation procedures, and evacuation drills. **Means of escape**, therefore, means the routes or channels, from any room or premises and within a room, which provide an exit from a building or space in case of any emergency. Routes must be planned, marked, and kept clear with no obstruction. The unit looks at the various forms of routes and factors influencing design, namely: layout, capacity, and safety features. **Emergency evacuation procedures** are the formal actions that should be undertaken once an emergency has occurred. These procedures should ensure the evacuation of people in a structured and safe manner. The procedures describe roles and responsibilities, timing, methods of communication, and coordination for the successful execution of the evacuation. The unit focuses on how to design, implement, and assess evacuation plans with an emphasis on differentiated procedures for different types of emergencies. **Evacuation drills** are crucial to ensure complete preparedness. Conducting such drills routinely enables them to know and be acquainted with evacuation routes, procedures, and respective roles played by people when calamities occur. Planning for effective drill implementation is discussed in this unit along with its review procedure and possible areas for improving evacuation tactics. Learners through this module are comprehensively equipped with the concept of emergency evacuation planning principles and practice and understand all requirements of effective evacuation design systems irrespective of the environment they are in and for increased safety and comfort for any person occupying it.

OBJECTIVES

1. To learn the principles behind designing and implementing effective means of escape (e.g., escape routes, emergency exits, stairwells).
2. To understand the components of a comprehensive emergency evacuation procedure, including roles and responsibilities of personnel, communication protocols, and coordination with emergency responders.
3. To explore the importance of conducting regular evacuation drills to ensure that employees and occupants are familiar with evacuation procedures.

8.1 MEANS OF ESCAPE

The means of escape are the routes and doors that occupants need to use to get out of a building in an emergency. It should be ensured that they are immediately available for use at all material times, which is whenever people (staff, visitors, students, or contractors) are on the premises.

Means of escape encompass several things, including:

- Exit doors.
- Emergency windows
- Stairways
- Fire escapes.

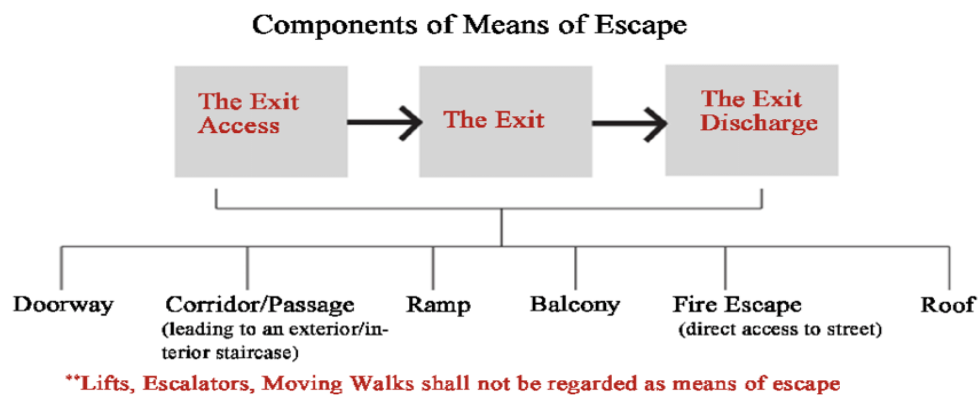


Figure 8.1: Component of Means of Escape

Safety regulations require buildings to have a sufficient number of means of escape, and for those to remain clear and unobstructed. They may also need to be constructed with flame-resistant materials to ensure that they remain safe to use during a fire. A means of escape is also sometimes referred to as an exit route or an escape route.

8.2 EMERGENCY EVACUATION PROCEDURES

Consider how the evacuation of the workplace will be arranged in light of the risk assessment and the other fire precautions that are in place. These arrangements will

form an integral part of the emergency plan and must be included in the instruction and training for employees.

Account must be taken not only of the people in the workplace (employed or otherwise) who may be able to make their escape but also those who may need assistance to escape, e.g., by having adequate staffing levels in premises providing treatment or care.

In most workplaces, the evacuation in case of fire will simply be using everyone reacting to the warning signal given when the fire is discovered and making their way, using escape, to a place of safety away from the workplace. This is known as a 'simultaneous' evacuation and will normally be initiated by the sounding of the general alarm over the fire warning system.

8.3 EVACUATION PLANNING

Although each emergency evacuation plan is different, the process for creating them is similar across different industries. Some things you need to consider when creating your emergency evacuation plan are:

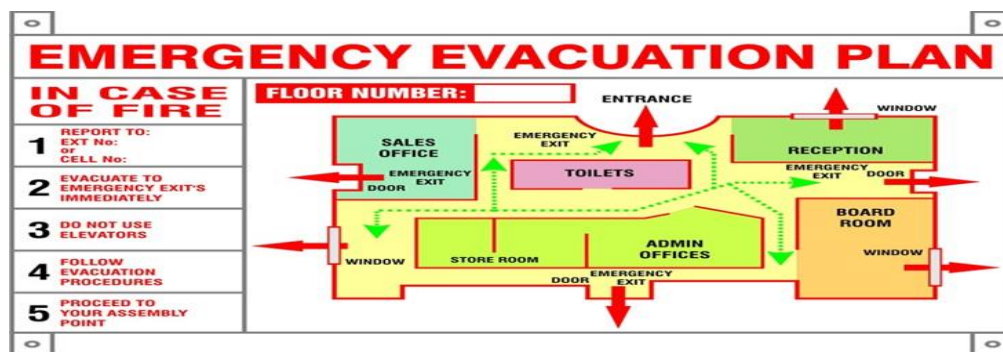


Figure 8.2: Sample of Emergency Evacuation Plan

1. **Regulatory requirements:** Make sure that your plan meets all necessary legal requirements for your industry and location.
2. **Your organization's needs:** Consider the size and complexity of your organization and is appropriate for your needs.

3. **Customizability:** Look for a template or digital solution that allows you to customize your emergency evacuation plan templates as needed.
4. **Chain of command:** Create and implement a clear chain of command to follow in case of emergencies and ensure everyone is aware of their respective roles and responsibilities.

8.3.1 What Should Be Included in A Fire Evacuation Plan?

When creating a fire evacuation plan, it is important to ensure that the document includes all of the relevant information. This should include:

1. Location of fire exits and escape routes.
2. Contact details of the fire department
3. Name and contact details of the person responsible for the evacuation.
4. How to respond to a fire alarm
5. Location of fire extinguishers
6. Location of assembly points
7. How to respond to a fire alarm and how to evacuate the building safely and effectively.



Figure 8.3: Fire Evacuation Plan

8.4 EVACUATION DRILLS

Evacuation drills include alarm activation to ensure fire protection and reliability, along with an orderly, disciplined evacuation, followed by a thorough inspection of the building to immediately rectify any code-related issues. Finally, an on-site discussion is held with students, staff, and faculty to evaluate and improve, when necessary, the performance and efficacy of these drills.



Figure 8.4: Example of Evacuation Drill

During the fire evacuation drills, you will hear a siren/horn and/or voice command announcement to evacuate. Ask People or the Public for full cooperation during the drills. The expected duration of each drill will be approximately 15-20 minutes. We recognize the drills may interrupt your schedule and we apologize for any inconvenience this may cause.

Please adhere to the following directions when the fire alarm sounds to safely evacuate the building:

1. Never ignore a fire alarm.
2. If a fire alarm sounds, evacuate immediately in a safe and orderly manner – do not run.

3. If needed, shut off any heat sources or equipment, quickly gather personal belongings (i.e., keys, purses, bag) and proceed to the nearest exit.
4. Remember to wear facial covering and maintain physical distancing.
5. It is recommended to have at least two ways out. Proceed to the nearest exit. Remember to use the stairs.
6. When exiting, move at least 150 ft. away or further, to a safe location from the building.
7. Do not re-enter the building until all clear to be returned inside by EHS personnel.
8. Tell someone about your location and ask them to notify the EHS personnel conducting the drill. If you are not sure if the fire alarm is a drill. Call the security or emergency helpline of the organization and tell them of your location and situation.
9. Remember to thoroughly wash your hands or use hand sanitizer after the drill.

SUMMARY

The means of escape in a building are crucial for occupants to evacuate safely during emergencies like fires. These routes include exit doors, emergency windows, stairways, and fire escapes. Safety regulations mandate these routes to be clear, unobstructed, and often constructed with flame-resistant materials. Emergency evacuation procedures must be well-planned, considering all occupants, including those who may need assistance. Evacuation plans should comply with regulatory requirements, fit the organization's needs, be customizable, and establish a clear chain of command. A fire evacuation plan should include details like fire exits, contact information for emergency services, responsible personnel, fire alarm response, fire extinguisher locations, assembly points, and evacuation procedures. Evacuation drills are essential for evaluating the effectiveness of emergency procedures, ensuring orderly evacuations, and identifying areas for improvement. During drills, occupants should follow instructions, evacuate calmly, maintain physical distancing, and wait for clearance before re-entering the building.

SELF-ASSESSMENT

Q. No.1. Fill in the blanks with the correct answers.

2. Safety regulations require buildings to have a sufficient number of.
3. During the _____ People will hear a siren/horn and/or voice command announcement to evacuate.
4. _____ includes Location of fire exits and escape routes.

Q. No. 2. Answer the following Questions.

1. Illustrate in detail the Evacuation Plan.
2. Write a note on the following.
 - i. Mean of Escape.
 - ii. Evacuation Drills.
 - iii. Emergency Evacuation Procedure.

Answers of Self-Assessment

Q. No.1. Answers

1. Means of Escape
2. Fire Evacuation Drills
3. Evacuation Plan

Q. No.2. Answers

For answers carefully read Unit 8.

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UNIT-9

TRAINING AND EDUCATION

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Ar. Nazia Iftakhar

INTRODUCTION

All employees, Students and guards should be trained to use fire extinguishers. It is recommended the training session covers how to manage; what type of extinguisher to use; and the PASS system of early-stage firefighting. It is also recommended that fire training be conducted periodically, or different segments may be provided training as per their availability. They should provide hands-on practice extinguishing a fire.

“The 'PASS' system stands for Pull, Aim, Squeeze and Sweep. It describes the stages in which a fire extinguisher should be operated and explains what each stage entails, giving enough information for the operator to use the extinguisher safely.”

A firefighter is a rescuer, primarily to extinguish hazardous fires that threaten life, property, and the environment as well as to rescue people and equipment from dangerous situations. A well-trained security guard, students and employees with an on-site fire extinguisher can also put out small, non-hazardous fires effectively. However, to do this safely, the employee must know the equipment and portable fire extinguisher limitations, in addition to the hazards associated with fighting fires. There may be situations where employee firefighting is warranted to give other workers time to escape or to prevent danger to others by the spread of a fire. However, the responsibility lies with the security department to prevent and react against any hazard.

OBJECTIVES:

1. To understand the importance of firefighting equipment.
2. To develop a comprehensive understanding of the role of firefighting equipment in fire safety.
3. To gain knowledge of routine maintenance and testing procedures for firefighting equipment, ensuring its operational readiness.
4. To highlight the significance of clear, visible, and standardized signage for firefighting equipment locations.

9.1 TRAINING ON FIRE FIGHTING EQUIPMENT

Training on firefighting equipment is crucial for ensuring the safety and effectiveness of firefighters in emergencies. Proper training helps firefighters become familiar with the various types of equipment, understand their limitations, and learn how to use them efficiently. Here are some key aspects to consider when training on firefighting equipment:

9.1.1 Familiarization:

Begin by familiarizing trainees with the different types of firefighting equipment, such as fire hoses, nozzles, extinguishers, and breathing apparatus. This includes understanding their purpose, operation, and maintenance requirements.

9.1.2 Hands-on practice:

Provide trainees with hands-on practice using the equipment. This could involve setting up mock scenarios where they have to use the equipment to extinguish a fire or perform rescue operations. This helps them gain confidence and develop the necessary skills to manage real-life situations.

9.1.3 Safety guidelines:

Emphasize the importance of safety guidelines while using firefighting equipment. Trainees should be taught how to avoid accidents, such as tripping over hoses or getting entangled in equipment, and how to manage emergencies, like equipment failure or gas leaks.

9.1.4 Teamwork and communication:

Firefighting is a team effort, and effective communication is vital for successful operations. Trainees should be taught how to work together, communicate effectively, and follow established protocols during emergencies.

9.1.5 Continuous training and updates:

Firefighting equipment and techniques are constantly evolving. Regular training sessions should be conducted to keep firefighters up to date with the latest advancements and best practices in the field.

9.1.6 Evaluation and feedback:

Assess the trainees' progress and provide constructive feedback to help them improve. This could involve written tests, practical assessments, or debriefing sessions after training exercises.

9.1.7 Real-life experience:

Whenever possible, provide trainees with opportunities to gain real-life experience by attending actual firefighting incidents under supervision. This helps them apply their knowledge and skills in real-world situations and learn from experienced firefighters.

9.2 AWARENESS

Raising awareness about the importance of training on firefighting equipment is essential for promoting safety and preparedness in communities. Here are some ways to increase awareness on this topic:

9.2.1 Educational campaigns:

Organize awareness campaigns through various media, such as social media, posters, flyers, and community events, to highlight the significance of firefighting equipment training. Share real-life examples of how proper training has saved lives and prevented property damage.

9.2.2 Collaborate with local fire departments:

Partner with local fire departments to host workshops, seminars, and demonstrations on fire safety and the proper use of firefighting equipment. This collaboration can help reach a wider audience and provide hands-on learning opportunities.

9.2.3 School programs:

Develop fire safety and firefighting equipment training programs for schools, targeting both students and teachers. This will help instill fire safety knowledge and practices at an early age, fostering a culture of preparedness and responsibility.

9.2.4 Media coverage:

Encourage local news outlets to cover stories related to fire safety and the importance of training on firefighting equipment. This can help spread the message to a larger audience and inspire others to take action.

9.2.5 Online resources:

Create informative online resources, such as blog posts, videos, and infographics, which explain the importance of firefighting equipment training and provide useful

tips for staying safe during fires. Share these resources on social media platforms and through email newsletters.

9.2.6 Community events:

Participate in local community events, such as fairs and festivals, to highlight fire safety demonstrations and provide information on firefighting equipment training. This can help engage the public and encourage them to take an active role in promoting fire safety.

9.2.7 Influencer Partnerships:

Collaborate with local influencers, such as bloggers, social media personalities, or community leaders, to spread awareness about the importance of firefighting equipment training. Their support can help amplify the message and reach a broader audience.

9.3 MAINTENANCE OF EQUIPMENT

Follow these suggested guidelines to ensure fire safety equipment is in working order and not in need of repair or additional maintenance.

9.3.1 Create a Maintenance Schedule:

Develop a maintenance schedule that outlines the inspection frequency and tasks for each piece of fire safety equipment in your facility. A professional fire protection company, like Fire Systems, Inc., can assist in setting up a customized schedule for your facility.

9.3.2 Hire Certified Professionals:

Use only certified fire protection professionals to conduct regular inspections and maintenance. Certified professionals are experts in the field who are trained to identify and address issues effectively.

9.3.3 Fire Alarms:

Test fire alarm systems regularly to ensure the alarms function correctly. Check alarm batteries and replace them at recommended intervals. Inspect alarm sensors and detectors for dust or obstructions that may affect alarm sensitivity.

9.3.4 Sprinkler Systems:

Conduct a visual inspection of sprinkler heads for signs of damage or corrosion. Ensure that valves and pipes are in good condition and free of leaks. Verify that water pressure is within the recommended range.

9.3.5 Fire Extinguishers:

Check the pressure gauge to ensure it is in the green zone. Examine the extinguisher's physical condition for dents, rust, or other damage. Make sure that the safety pin and tamper seal are intact.

9.3.6 Emergency Lighting:

Test emergency lighting to confirm it illuminates correctly during a power outage. Replace burned-out bulbs promptly. Ensure that exit signs are illuminated and legible.

9.3.7 Fire Doors:

Inspect fire doors for damage, wear, and proper operation. Check that door closes are functioning as intended. Ensure that fire-rated seals and gaskets are in place and intact.

9.3.8 Smoke and Carbon Monoxide Detectors:

Change the batteries in smoke and carbon monoxide detectors at least annually. Perform a test to confirm the alarms sound as expected. Clean detectors regularly to prevent dust buildup.

9.3.9 Fire Suppression Systems:

Schedule regular professional inspections of fire suppression systems, such as kitchen hood suppression or clean agent systems. Ensure that these systems are free of obstruction or blockages that may hinder their operation.

9.3.10 Record Keeping:

Maintain detailed records of all inspections, maintenance, and repairs. Accurate documentation is essential for compliance and helps track the history of each piece of equipment.

9.3.11 Signs of Required Maintenance or Repairs

It is essential to be vigilant for signs that fire safety equipment may require maintenance or repairs between scheduled inspections. Here are some signs of

damage or wear that would signify the need for repair:

1. **False Alarms:** Frequent false alarms from smoke detectors or fire alarms may indicate a problem with the equipment.
2. **Leaking Sprinklers:** Water leaks or visible corrosion on sprinkler heads should be addressed immediately.
3. **Expired Fire Extinguisher Tags:** If the inspection tag on a fire extinguisher is past its expiration date, it may need to be serviced or replaced.
4. **Dim Emergency Lighting:** Dim or flickering emergency lighting suggests the need for bulb replacement or wiring repairs.
5. **Obstructed Equipment:** Fire safety equipment obstructed by storage or other materials can impede its functionality and require immediate attention.
6. **Visible Damage:** Any visible damage to equipment, such as dents in fire extinguishers or cracked exit signs, should be addressed promptly.

9.4 SIGNAGE

“Signage graphic designs, as symbols, emblems, or words, are used especially for identification or as a means of giving directions or warning.”

Fire safety signs play a crucial role in ensuring the safety of occupants and property in various settings, such as homes, offices, schools, and public spaces. These signs help communicate essential information about fire safety measures, emergency procedures, and potential hazards. Some common types of fire safety signs include:

9.4.1 Fire Exit Signs:

These signs direct people to the nearest safe exit in case of a fire or emergency. They are typically illuminated or have a red background with white or yellow letters for easy visibility in low-light conditions.



Figure 9.1: Fire Exit Signs

9.4.2 No Smoking Signs:

These signs prohibit smoking in specific areas to reduce the risk of fire ignition. They usually feature a red background with a cigarette or match being crossed out.



Figure 9.2: No Smoking Signs

9.4.3 Fire Extinguisher Signs:

These signs indicate the location of fire extinguishers, helping people quickly access and use them to control small fires. The signs usually depict a fire extinguisher on a green or white background.



Figure 9.3: Fire Extinguisher Signs

9.4.4 Fire Alarm Signs:

These signs show the location of fire alarm pull stations, which are used to activate the building's fire alarm system. They often have a red background with a picture of a hand pulling a cord or a loudspeaker.



Figure 9.4: Fire Alarm Signs

9.4.5 Emergency Lighting Signs:

These signs indicate the location of emergency lighting systems, which provide temporary illumination during power outages or emergencies. They typically have a green background with a light bulb symbol.



Figure 9.5: Emergency Lighting Signs

9.4.6 Assembly Point Signs:

These signs direct people to designated assembly areas outside the building, where they can gather after evacuation for a headcount and further instructions. They usually have a green or blue background with an assembly symbol or text.



Figure 9.6: Assembly Point Signs

9.4.7 Hazard Signs:

These signs warn about potential fire hazards, such as flammable materials, high-risk areas, or electrical equipment. They may have different colours depending on the type of hazard and use symbols or text to convey the message.

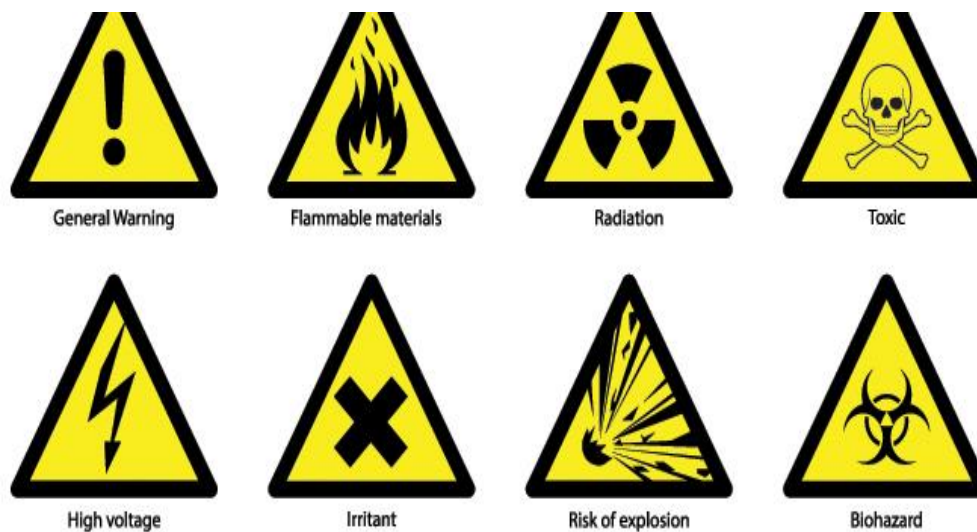


Figure 9.7: Hazard Signs

9.4.8 Fire Doors and Access Signs:

These signs indicate the presence of fire doors or access routes that help contain fires and facilitate evacuation. They often have a red background with a fire door symbol or text.



Figure 9.8: Fire Doors and Access Signs

9.4.9 Fire Hose Cabinet Signs:

These signs point out the location of fire hose cabinets, which store fire hoses and nozzles for use in fighting fires. They usually depict a fire hose on a green or white background.



Figure 9.9: Fire Hose Cabinet Signs

9.4.10 Evacuation Diagrams:

These signs display floor plans with marked exit routes, assembly points, and other critical information to help people navigate during an emergency evacuation. They are typically found near staircases, elevators, and other key locations.

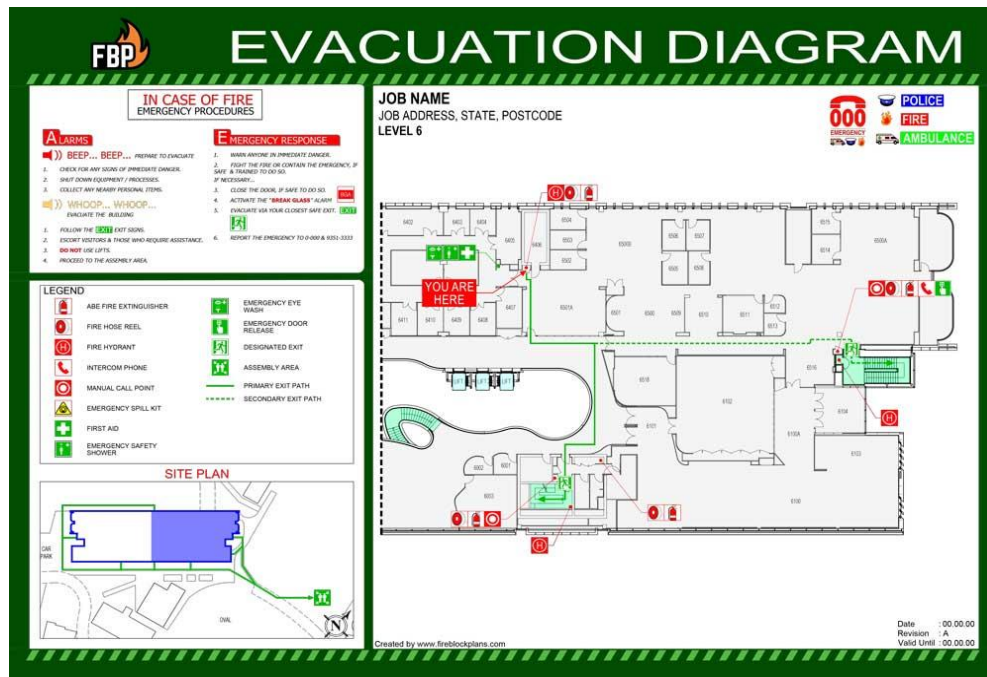


Figure 9.10: Evacuation Diagrams

Ensure that fire safety signs are visible, well-lit, and easily understandable to promote quick and effective action during emergencies. Regularly inspect and replace them as needed to maintain their effectiveness.

SUMMARY

The importance of training employees, students, and guards in fire extinguisher usage for small fires. Periodic sessions covering handling techniques and the PASS system are necessary, with hands-on practice crucial for confidence and skill development. Promoting fire safety awareness and regular maintenance of equipment contributes to community preparedness. Fire safety signs should be visible and easy to understand during emergencies

SELF-ASSESSMENT

Q. No.1. Fill in the blanks with the correct answers.

1. PASS stands for_____.
2. Provide trainees with _____practice using the equipment.
3. _____is a team effort, and effective communication is vital for successful operations.
4. Inspect _____doors for damage, wear, and proper operation.

Q. No. 2. Answer the following Questions.

1. Define the following terms:
 - i. Training.
 - ii. Firefighter.
 - iii. Signage.
 - iv. PASS
2. What are signs that indicate the requirement of fire safety equipment maintenance?
3. How to spread awareness regarding the Training of Firefighting Equipment?
4. Write a detailed note on Training of Firefighting Equipment.
5. List the names of fire safety signs along with an explanation and illustration.

Answers of Self-Assessment

Q. No.1. Answers

1. Pull, Aim, Squeeze and Sweep

2. hands-on
3. Firefighting
4. Fire

Q. No.2. Answers

For answers carefully read Unit 9.

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