Solar PV System Installation and Maintenance

Level-IV

Learning Guide - 19

Unit of Competence	**Develop and Connect Electrical Control Circuits**
Module Title	**Developing and Connecting Electrical Control Circuits**
LG Code	**EIS PIM4 M05 LO1-LG19**
TTLM Code	**EIS PIM4 TTLM 0920v1**

LO1-Develop and prepare to connect electrical control circuit

ADRA ETHIOPIA

Instruction Sheet	Learning Guide-19

This learning guide is developed to provide you the necessary information, knowledge, skills and attitude regarding the following content coverage and topics:

- Identifying, obtaining and understanding OHS procedures
- Establishing OHS risk control measures
- Identifying safety hazards, which have not previously noted?
- Controlling and determining scenarios documents
- Documenting agreement for the control scenarios
- Establishing schematic arrangement for controlling circuit
- Obtaining and establishing materials needed to connect circuit
- Obtaining tools and equipment to connect control circuits
- Checking procedures for correct operation and safety

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:-

- Identify, obtain and understand OHS procedures
- Establish OHS risk control measures
- Identify safety hazards, which have not previously noted?
- Control and determine scenarios documents
- Document agreement for the control scenarios
- Establish schematic arrangement for controlling circuit
- Obtain and establishing materials needed to connect circuit
- Obtain tools and equipment to connect control circuits
- Check procedures for correct operation and safety.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks

Information Sheet-1	Identifying, obtaining and understanding OHS procedures

1.1 Purpose

The purpose of the Occupational Health and Safety (OHS) policies and procedures is to guide and direct all employees to work safely and prevent injury, to themselves and others. All employees are encouraged to participate in developing, implementing, and enforcing Health and Safety policies and procedures. All employees must take all reasonable steps to prevent accidents and never sacrifice safety for expedience. Its goal is to eliminate or minimize hazards that can cause accidents.

Everyone is committed to the goal of providing and maintaining a healthy and safe working environment, with a view to continuous improvement. This goal is only achievable by adherence to established objectives striving to exceed all obligations under applicable legislation, and by fostering an enthusiastic commitment to health, safety and the environment within the work area, personnel, contractors and visitors.

1.2 Electrical Safety Procedures

Electrical Safety Procedures are an essential part of any electrical safety program. Electrical workers must know where the disconnect switches and electrical panels are located in the workplace so that the electrical equipment can be quickly de-energized when an electrical accident occurs. Posting the location of the electrical panel on servicing equipment is also a great way to enhance electrical safety. Establishing strict Electrical Safety Procedures must include properly labeling electrical equipment. This means that disconnect switches and electrical panels are clearly labeled and in clear view to show what equipment or power source that the electrical equipment control. At least three feet must be clear from obstruction at all times so that electrical panels can be safely operated and maintained. Electrical fires and electrical shock kill electrical workers every year, so it's important to establish and adhere to any set of established electrical safety procedures.

Ensure that plugs and cords are disconnected from all equipment and that no one else can reactivate this equipment until all work is done. When servicing is being done on hard-wired equipment, the circuit breaker has to be turned off and locked and tagged with a tag and special padlock. Work on live equipment can only be done by electricians with Lockout/Tag out training. Most Electrical Safety Procedures include a way to isolate Flammables, Solvents and Chemicals from a point of ignition. Electrical Safety Procedures also means keeping Electrical Equipment Dry to insure that all electrical equipment is kept away from damp or wet locations (unless equipment is specifically rated for these conditions). An Electrical Safety Procedures include keeping the electrical workplace dry.

Electrical Safety Procedures includes trigger the fire alarm and do not attempt to put the electrical fire out using water. Electrical Safety Procedures also include avoiding Contact with Shock Victims. Avoid touching anyone (or any kind of electrical equipment) that falls victim to electrical shock.

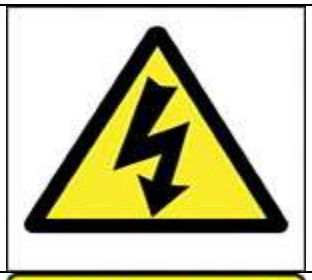
1.3 Electrical Safety

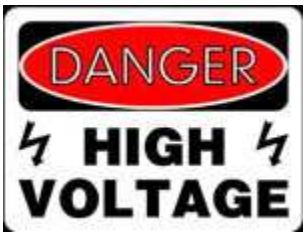
Accidental contact with electrical components may have deadly consequences. Always review the manufacturer's recommended operating practices before using new electrical appliances, tools, and equipment. Use the following guidelines to reduce the risk of personal injury.

- All electrical tools and appliances will be double insulated or have a three-prong plug (fully grounded).
- Only qualified and authorized electricians are allowed to service and repair electrical appliances, tools, and equipment.
- Before operating electrical-powered tools and equipment, ensure that you are working on a dry surface.
- Tools with damaged cords, grounds, and housing units are to be tagged “Out of Service” and sent for repair.
- Damaged extension cords and defective equipment are to be tagged “Out of Service” and repaired, removed, or replaced as warranted.

- Tools with electrical arcing brushes should be removed from service when you feel any tingling during use.
- Missing or damaged ground plugs of any appliance, tool, or piece of equipment are to be repaired before use.
- Always stand to the side of a service box when resetting a breaker to reduce the risk of injury if an arc flash occurs.
- All electrical tools must be CSA approved.
- Disconnect power tools from the power source before making adjustments.
- Extension cords must be of the outdoor type, rated for 300 volts, and have an insulated grounding conductor.
- Plug extension cords into Class A ground fault circuit interrupters (GFCIs). When built-in GFCI receptacles are not available, protection can be attained with an in-line GFCI plugged directly into the supply receptacle.
- Rechargeable tools do not have the electrical hazards of plug-in versions. However, they may not be as powerful. Caution must be taken not to overcharge the battery, which can reduce the tool's capacity. As best practice, keep an alternate battery pack charging at all times.

Table 1: Some Electrical Safety Symbols

s/n	Description	Symbol
1	The common symbol for electricity is a lightning bolt.	
2	Voltage or Shock Hazard Symbol	

3	Buried Cable Symbol	
4	Danger/Safety (Universal)	
5	Restricted Areas	
6	Electrical Devices	

Self-Check – 1	Written Test

Instruction: Follow the below selected instruction

The following are true or false items, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	An Electrical Safety Procedures include keeping the electrical workplace wet and dirty
	True or false:
2	Electrical accidents can occur from under loaded circuits or wires.
	True or false:
3	Electrical Safety Procedures are an essential part of any electrical safety program.
	True or false

Note: Satisfactory rating - 2 points Unsatisfactory - below 2 points

Information Sheet-2	Establishing OHS risk control measures

2.1 Introduction

Effective controls protect workers from workplace hazards; help avoid injuries, illnesses, and incidents; minimize or eliminate safety and health risks; and help employers provide workers with safe and healthful working conditions. The processes described in this section will help employers prevent and control hazards identified in the previous section.

2.2 To effectively control and prevent hazards, employers should

- Involve workers, who often have the best understanding of the conditions that create hazards and insights into how they can be controlled.
- Identify and evaluate options for controlling hazards, using a "hierarchy of controls."
- Use a hazard control plan to guide the selection and implementation of controls, and implement controls according to the plan.
- Develop plans with measures to protect workers during emergencies and non-routine activities.
- Evaluate the effectiveness of existing controls to determine whether they continue to provide protection, or whether different controls may be more effective. Review new technologies for their potential to be more protective, more reliable, or less costly.

2.3 Action items to Establish OHS risk control measures

Action item 1: Identify control options

A wealth of information exists to help employers investigate options for controlling identified hazards. Before selecting any control options, it is essential to solicit workers' input on their feasibility and effectiveness.

- **How to accomplish it**

Collect, organize, and review information with workers to determine what types of hazards may be present and which workers may be exposed or potentially exposed. Information available in the workplace may include:

- ✓ Review sources such as OSHA standards and guidance, industry consensus standards, National Institute for Occupational Safety and Health (NIOSH) publications, manufacturers' literature, and engineering reports to identify potential control measures. Keep current on relevant information from trade or professional associations.
- ✓ Investigate control measures used in other workplaces and determine whether they would be effective at your workplace.
- ✓ Get input from workers who may be able to suggest and evaluate solutions based on their knowledge of the facility, equipment, and work processes.
- ✓ For complex hazards, consult with safety and health experts, including OSHA's On-site Consultation Program.

- **How to accomplish it**
  - ✓ Eliminate or control all serious hazards (hazards that are causing or are likely to cause death or serious physical harm) immediately.
  - ✓ Use interim controls while you develop and implement longer-term solutions.
  - ✓ Select controls according to a hierarchy that emphasizes engineering solutions (including elimination or substitution) first, followed by safe work practices, administrative controls, and finally personal protective equipment.
  - ✓ Avoid selecting controls that may directly or indirectly introduce new hazards. Examples include exhausting contaminated air into occupied work spaces or using hearing protection that makes it difficult to hear backup alarms.
  - ✓ Review and discuss control options with workers to ensure that controls are feasible and effective.
  - ✓ Use a combination of control options when no single method fully protects workers.

- ✓ Note: Whenever possible, select equipment, machinery, and materials that are inherently safer based on the application of "Prevention through Design" (PtD) principles. Apply when making your own facility, equipment, or product design decisions. For more information, see the link to the NIOSH PtD initiative in Additional Resources.

Action item 2: Develop and update a hazard control plan

A hazard control plan describes how the selected controls will be implemented. An effective plan will address serious hazards first. Interim controls may be necessary, but the overall goal is to ensure effective long-term control of hazards. It is important to track progress toward completing the control plan and periodically (at least annually and when conditions, processes or equipment change) verify that controls remain effective.

- **How to accomplish it**
  - ✓ List the hazards needing controls in order of priority.
  - ✓ Assign responsibility for installing or implementing the controls to a specific person or persons with the power or ability to implement the controls.
  - ✓ Establish a target completion date.
  - ✓ Plan how you will track progress toward completion.
  - ✓ Plan how you will verify the effectiveness of controls after they are installed or implemented.

Action item 3: Select controls to protect workers during non-routine operations and emergencies

The hazard control plan should include provisions to protect workers during non-routine operations and foreseeable emergencies. Depending on your workplace, these could include fires and explosions; chemical releases; hazardous material spills; unplanned equipment shutdowns; infrequent maintenance activities; natural and weather disasters; workplace violence; terrorist or criminal attacks; disease outbreaks (e.g., pandemic influenza); or medical emergencies. Non routine tasks, or tasks workers don't normally do, should be approached with particular caution. Prior to initiating such work, review job

hazard analyses and job safety analyses with any workers involved and notify others about the nature of the work, work schedule, and any necessary precautions.

- **How to accomplish it**
  - ✓ Develop procedures to control hazards that may arise during non-routine operations (e.g., removing machine guarding during maintenance and repair).
  - ✓ Develop or modify plans to control hazards that may arise in emergency situations.
  - ✓ Procure any equipment needed to control emergency-related hazards.
  - ✓ Assign responsibilities for implementing the emergency plan.
  - ✓ Conduct emergency drills to ensure that procedures and equipment provide adequate protection during emergency situations.

Note: Depending on your location, type of business, and materials stored or used on site, authorities including local fire and emergency response departments, state agencies, the U.S. Environmental Protection Agency, the Department of Homeland Security, and OSHA may have additional requirements for emergency plans. Ensure that your procedures comply with these requirements.

Action item 4: Implement selected controls in the workplace

Once hazard prevention and control measures have been identified, they should be implemented according to the hazard control plan.

- **How to accomplish it**
  - ✓ Implement hazard control measures according to the priorities established in the hazard control plan.
  - ✓ When resources are limited, implement measures on a "worst-first" basis, according to the hazard ranking priorities (risk) established during hazard identification and assessment. (Note, however, that regardless of limited resources, employers have an obligation to protect workers from recognized, serious hazards.)

- ✓ Promptly implement any measures that are easy and inexpensive—e.g., general housekeeping, removal of obvious tripping hazards such as electrical cords, basic lighting—regardless of the level of hazard they involve.

Action item 5: Follow up to confirm that controls are effective

To ensure that control measures are and remain effective, employers should track progress in implementing controls, inspect and evaluate controls once they are installed, and follow routine preventive maintenance practices.

- **How to accomplish it**
  - ✓ Track progress and verify implementation by asking the following questions:
    - ➢ Have all control measures been implemented according to the hazard control plan?
    - ➢ Have engineering controls been properly installed and tested?
    - ➢ Have workers been appropriately trained so that they understand the controls, including how to operate engineering controls, safe work practices, and PPE use requirements?
    - ➢ Are controls being used correctly and consistently?
  - ✓ Conduct regular inspections (and industrial hygiene monitoring, if indicated) to confirm that engineering controls are operating as designed.
  - ✓ Evaluate control measures to determine if they are effective or need to be modified. Involve workers in the evaluation of the controls. If controls are not effective, identify, select, and implement further control measures that will provide adequate protection.
  - ✓ Confirm that work practices, administrative controls, and personal protective equipment use policies are being followed.
  - ✓ Conduct routine preventive maintenance of equipment, facilities, and controls to help prevent incidents due to equipment failure.

- **What are the five steps to risk assessment?**
  - ✓ Step 1: Identify hazards, i.e. anything that may cause harm. Employers have a duty to assess the health and safety **risks** faced by their workers

- ✓ Step 2: Decide who may be harmed, and how
- ✓ Step 3: Assess the risks and take action
- ✓ Step 4: Make a record of the findings
- ✓ Step 5: Review the risk assessment.

- **Hazard Prevention and Control**

Effective controls protect workers from workplace hazards; help avoid injuries, illnesses, and incidents; minimize or eliminate safety and health risks; and help employers provide workers with safe and healthful working conditions. The processes described in this section will help employers prevent and control hazards identified in the previous section.

- **To effectively control and prevent hazards, employers should:**
  - ✓ Involve workers, who often have the best understanding of the conditions that create hazards and insights into how they can be controlled.
  - ✓ Identify and evaluate options for controlling hazards, using a "hierarchy of controls."
  - ✓ Use a hazard control plan to guide the selection and implementation of controls, and implement controls according to the plan.
  - ✓ Develop plans with measures to protect workers during emergencies and non-routine activities.
  - ✓ Evaluate the effectiveness of existing controls to determine whether they continue to provide protection, or whether different controls may be more effective. Review new technologies for their potential to be more protective, more reliable, or less costly.

- **Risk management**

Risk management is outlined in the risk management framework and includes a risk matrix. This risk matrix has been incorporated into the Vault online health and safety management system, and hazards are risk assessed based on this matrix. Hazards are things that exist and can cause harm (such as a drill press), risk is the combined likelihood of that hazard being in use or circumstance that allows harm. For example, a

guarded drill press that is used by a trained and experiences person and it is the right tool for the job is unlikely to cause harm and be used in a same manner i.e. the risk of injury is low. The purpose of risk and hazard management is to ensure that the work that is required to be done, with the tools and processes is managed to minimize the risk of harm to any person on campus.

- **Control of risks and hazards**

Vault, the online health and safety management system, records the risks or hazards identified, the risk or hazard controls and generates reports. The DHSO is primarily responsible for maintaining the risk and hazard register for the department or work area. Detailed training on Vault is provided to DHSOs. You can request of copy of the Hazard Register for your work area from your DHSO or HOD. All other workers, students and visitors are able to identify risks and hazards through the health and safety hazard management web page. An overview of the risk and hazard management process is outlined below. As a starting point, use the hazard matrix to identify what generic hazards apply to the department or work area.

- **Evaluation**

The risk and hazard register is required to be reviewed at least annually, and after any significant event involving that risk or hazard. The evaluation process is to consider the current state of risk and hazard controls, the industry state of knowledge of risk and hazard controls, including any new research or practices, and analysis of any events and audit results related to the risks and hazards being reviewed. Where the risk and hazard controls require improvement or modification, the register must be updated and all workers and students notified of the required changes.

Self-Check -2	Written Test

Instruction: Follow the below selected instruction

The following are true or false items, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	Implement hazard control measures according to the priorities established in non-hazardous control plan.
	True or false:
2	Risk management is outlined in the risk management framework and includes a risk matrix
	True or false:
3	The risk and hazard register is required to be reviewed at least annually, and after any significant event involving that risk or hazard.
	True or false:

Note: Satisfactory rating - 2 points Unsatisfactory - below 2 points

Information Sheet-3	Identifying safety hazards, which have not previously noted

3.1 Introduction

Safety hazards are unsafe working conditions that that can cause injury, illness, and death. Safety hazards are the most common workplace risks. They include: Anything that can cause spills or trips such as cords running across the floor or ice.

- **The six main categories of hazards are:**
  - ✓ Biological. Biological hazards include viruses, bacteria, insects, animals, etc., that can cause adverse health impacts
  - ✓ Chemical. Chemical hazards are hazardous substances that can cause harm
  - ✓ Physical
  - ✓ Safety
  - ✓ Ergonomic
  - ✓ Psychosocial.

- **Elements of an Effective Safety Culture**
  - ✓ Responsibility. Companies with strong safety cultures share the value of responsibility
  - ✓ Accountability. Managers must be held accountable to lead by example each and every day
  - ✓ Clear Expectations. Safety expectations need to be set and communicated to everyone in the organization
  - ✓ Ethics.

- **What are workplace hazards?**

Simply put, workplace hazards are any aspect of work that cause health and safety risks and have the potential to harm. Some hazards are more likely to be present in some workplaces than others, and depending on the work that you do; there will be hazards that are more or less relevant to your business.

What are the most common workplace hazards?

There are many types of workplace hazards, which tend to come under four main categories:

- ✓ **physical hazards** – the most common workplace hazards, including vibration, noise and slips, trips and falls;
- ✓ **ergonomic hazards** – physical factors that harm the musculoskeletal system, such as repetitive movement, manual handling and poor body positioning;
- ✓ **chemical hazards** – any hazardous substance that can cause harm to your employees;
- ✓ **Biological hazards** – bacteria and viruses that can cause health effects, such as hepatitis, HIV/AIDS and Legionnaire's disease.

- **Common health risks**

Some of the most common health risks associated with workplace hazards include:

- ✓ breathing problems;
- ✓ skin irritation;
- ✓ damage to muscles, bones and joints;
- ✓ hearing damage;
- ✓ Reduced wellbeing.

- **How to prevent workplace hazards**

The best way to protect yourself and your employees from workplace hazards is to identify and manage them and take reasonable steps to prevent their potential to harm.

In order to control workplace hazards and eliminate or reduce the risk, you should take the following steps:

- ✓ identify the hazard by carrying out a workplace risk assessment;
- ✓ determine how employees might be at risk;
- ✓ evaluate the risks;
- ✓ Record and review hazards at least annually, or earlier if something changes.

One of the "root causes" of workplace injuries, illnesses, and incidents is the failure to identify or recognize hazards that are present, or that could have been anticipated. A critical element of any effective safety and health program is a proactive, ongoing process to identify and assess such hazards.

3.2 To identify and assess hazards, employers and workers:

Health and safety documentation is developed as per the procedural guidelines. All polices, guidelines and codes of practice are forwarded to the Policy Framework group prior to submission to the Vice Chancellor for authorization. OHS Management System has established documented procedures to ensure the following are conducted:

- hazard identification,
- hazard and risk assessment, and control of risks and hazards
- evaluation of effectiveness of control measures

Health and Safety Policies are developed for high risk activities where there is regulatory or industry specific health and safety guidance documentation. Policies are developed through the policy development procedure to ensure compliance with the University policy framework, sufficient consultation and an outcome that is fit for purpose. For further details see the

- ✓ Policy Development document
- ✓ Purchasing OHS requirements procedure
- ✓ Personal Protective Equipment and Clothing

- **Hazard identification**

The hazard matrix is a starting point for the hazard identification process. It identifies which of the hazards apply to your work area. Vault, the online health and safety management system, contains generic hazards and provides controls and information sources.

The purpose of the Health and Safety policies and procedures is to guide and direct all employees to work safely and prevent injury, to themselves and others. All employees are encouraged to participate in developing, implementing, and enforcing Health and Safety policies and procedures.

- **What is a Safety and Health Management System?**

A safety and health management system means the part of the Organization's management system which covers:

- ✓ the health and safety work organization and policy in a company
- ✓ the planning process for accident and ill health prevention
- ✓ the line management responsibilities and
- ✓ The practices, procedures and resources for developing and implementing, reviewing and maintaining the occupational safety and health policy.

The system should cover the entire gambit of an employer's occupational health and safety organization. The key elements of a successful safety and health management system are:

- **Policy and commitment**

The workplace should prepare an occupational safety and health policy programme as part of the preparation of the Safety Statement required by Section 20 of the Safety, Health and Welfare at Work Act 2005. Effective safety and health policies should set a clear direction for the organization to follow. They will contribute to all aspects of business performance as part of a demonstrable commitment to continuous improvement. Responsibilities to people and the working environment will be met in a way that fulfils the spirit and letter of the law. Cost-effective approaches to preserving and developing human and physical resources will reduce financial losses and liabilities. In a wider context, stakeholders' expectations, whether they are shareholders, employees or their representatives, customers or society at large, can be met.

- **Planning**

The workplace should formulate a plan to fulfill its safety and health policy as set out in the Safety Statement. An effective management structure and arrangements should be

put in place for delivering the policy. Safety and health objectives and targets should be set for all managers and employees.

- **Implementation and operation**

For effective implementation, organizations should develop the capabilities and support mechanisms necessary to achieve the safety and health policy, objectives and targets. All staff should be motivated and empowered to work safely and to protect their long-term health, not simply to avoid accidents.

These arrangements should be:

- ✓ underpinned by effective staff involvement and participation through appropriate consultation, the use of the safety committee where it exists and the safety representation system and,
- ✓ Sustained by effective communication and the promotion of competence, which allows all employees and their representatives to make a responsible and informed contribution to the safety and health effort.

There should be a planned and systematic approach to implementing the safety and health policy through an effective safety and health management system. The aim is to minimize risks. Risk Assessment methods should be used to determine priorities and set objectives for eliminating hazards and reducing risks. Wherever possible, risks should be eliminated through the selection and design of facilities, equipment and processes.

- **Measuring performance**

The organization should measure, monitor and evaluate safety and health performance. Performance can be measured against agreed standards to reveal when and where improvement is needed. Active self-monitoring reveals how effectively the safety and health management system is functioning. Self-monitoring looks at both hardware (premises, plant and substances) and software (people, procedures and systems, including individual behaviour and performance). If controls fail, reactive monitoring should find out why they failed, by investigating the accidents, ill health or incidents, which could have caused harm or loss.

The objectives of active and reactive monitoring are:

- ✓ To determine the immediate causes of substandard performance
- ✓ To identify any underlying causes and implications for the design and operation of the safety and health management system.

- **Auditing and reviewing performance**

The organization should review and improve its safety and health management system continuously, so that its overall safety and health performance improves constantly. The organization can learn from relevant experience and apply the lessons. There should be a systematic review of performance based on data from monitoring and from independent audits of the whole safety and health management system.

- **Performance should be assessed by:**
  - ✓ internal reference to key performance indicators
  - ✓ External comparison with the performance of business competitors and best practice in the organization's employment sector.

Many companies now report on how well they have performed on worker safety and health in their annual reports and how they have fulfilled their responsibilities with regard to preparing and implementing their Safety Statements.

What issues should a review of the safety and health management system cover?

An organization should carry out an initial review of the safety and health management system, and follow this up with periodic reviews. The initial review should compare existing safety and health practice with:

- ✓ the requirements of safety and health legislation
- ✓ the provisions set out in the organization's Safety Statement
- ✓ safety and health guidance in the organization
- ✓ existing authoritative and published safety and health guidance
- ✓ best practice in the organization's employment sector

The following checklist may be used for the review

- ✓ Is the Safety Statement clear and concise so that it can be read and understood by those who may be at risk?
- ✓ Is the Safety Statement available at the workplace to which it relates and are workers given relevant extracts where they are at specific risk?
- ✓ Is the overall safety and health policy of the organization and the internal structure for implementing it adequate, e.g. are responsibilities of named persons clearly outlined?
- ✓ Does the Safety Statement contain a systematic identification of hazards and an assessment of risks for the workplace(s) it covers?
- ✓ Are Risk Assessments being carried out on a regular basis as risks change and are the necessary improvements made to keep the safety and health management system up to date?
- ✓ Are the necessary safety control measures required for a safe workplace identified and implemented, e.g. the provision of safe access and egress, good housekeeping, clear passageways and internal traffic control?
- ✓ Are written safe procedures for those operations that require them available

- **Here are some tips to help make your workplace safe.**
  - ✓ Understand the risks
  - ✓ Reduce workplace stress
  - ✓ Take regular breaks
  - ✓ Avoid stooping or twisting
  - ✓ Use mechanical aids whenever possible
  - ✓ Protect your back
  - ✓ Wear protective equipment to suit the task
  - ✓ Stay sober.

SAFETY GUIDELINES

- Protect people from injury
- Protect equipment from damage
- Protect the environment from contamination

FIRE SAFETY GUIDELINES

- Know the location of fire extinguishers, how to use them and which to use for electrical fires and for combustible fires.
- Find an escape route in case a fire gets out of control.
- Know how to contact emergency services quickly
- Keep the workspace clean.
- Keep most solvents in a separate area.

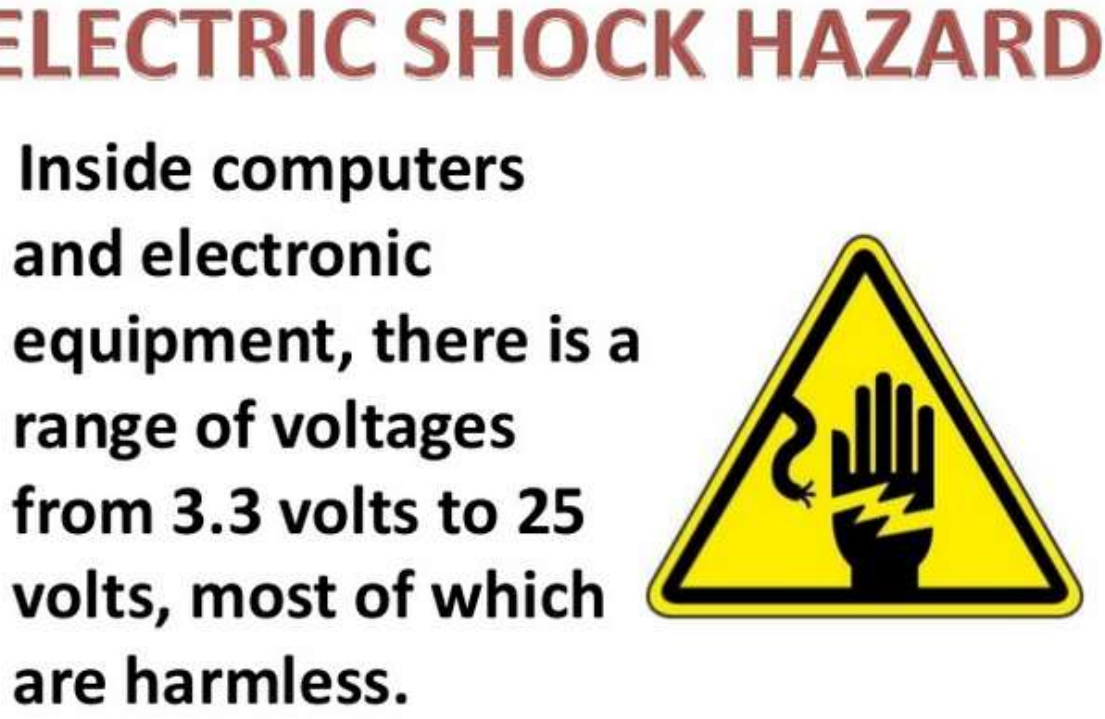


Figure 1: Electrical shock hazards

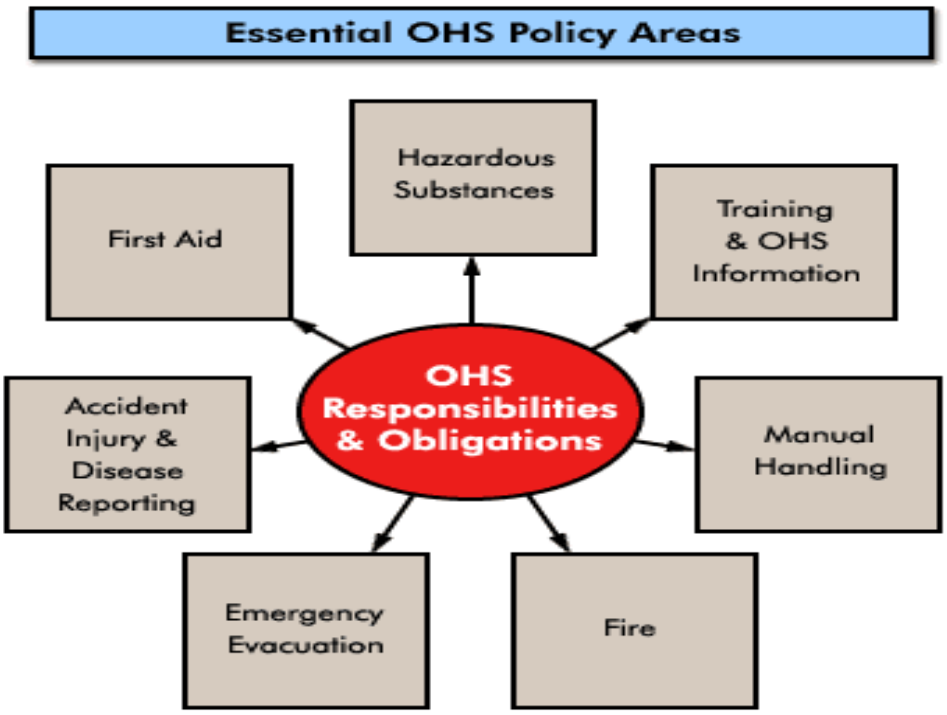


Figure 2: Essential OHS areas

OHS in the workplace

All sport and recreation workplaces should:

1. Commit to OHS – understand the law and responsibilities
2. Plan to work safely – Identifying hazards and managing risks
3. Consultation – communicating roles and responsibilities with employees and volunteers
4. Develop OHS procedures for staff to follow
5. Incident notification – Notifying governing bodies of a serious incident
6. Inform and train workers and volunteers
7. Monitor and review OHS policies and procedures

Workplace OHS policies and procedures

A typical OHS policy includes procedures for the following:

- Emergency situation plan
- First aid plan
- Ground and venue checklist
- Handling chemicals checklist
- Induction processes for new staff, members and volunteers
- Risk identification for members and participants

It is the responsibility of management to ensure a OHS policy and procedure in place

Figure 3: Importance of work health and safety policies and procedures

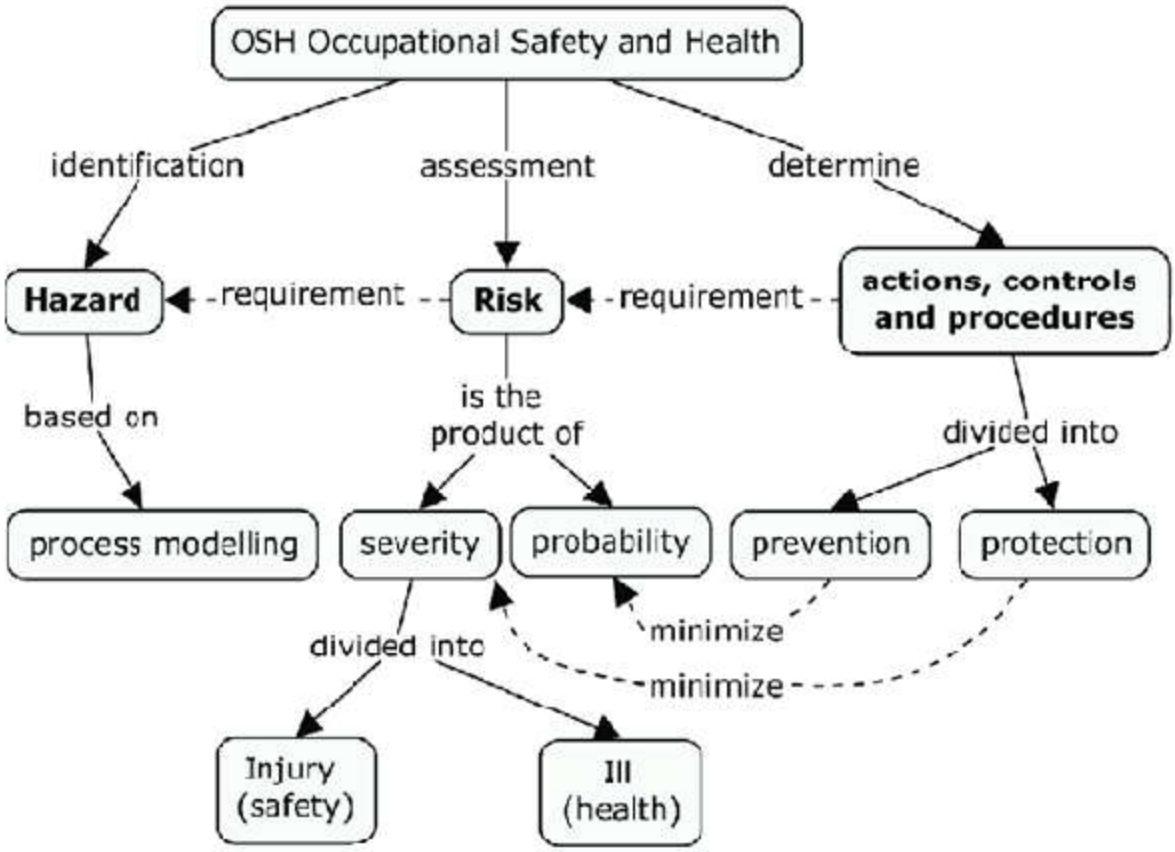


Figure 4: OSH occupational safety and health

3.3 Action items Identify safety hazards, which have not previously noted

Action item 1: Collect existing information about workplace hazards

Information on workplace hazards may already be available to employers and workers, from both internal and external sources.

How to accomplish it

Collect, organize, and review information with workers to determine what types of hazards may be present and which workers may be exposed or potentially exposed. Information available in the workplace may include:

- Equipment and machinery operating manuals.
- Safety Data Sheets (SDS) provided by chemical manufacturers.
- Self-inspection reports and inspection reports from insurance carriers, government agencies, and consultants.

- Records of previous injuries and illnesses, such as OSHA 300 and 301 logs and reports of incident investigations.
- Workers' compensation records and reports.
- Patterns of frequently-occurring injuries and illnesses.
- Exposure monitoring results, industrial hygiene assessments, and medical records (appropriately redacted to ensure patient/worker privacy).
- Existing safety and health programs (lockout/tagout, confined spaces, process safety management, personal protective equipment, etc.).
- Input from workers, including surveys or minutes from safety and health committee meetings.
- Results of job hazard analyses, also known as job safety analyses.

Action item 2: Inspect the workplace for safety hazards

Hazards can be introduced over time as workstations and processes change, equipment or tools become worn, maintenance is neglected, or housekeeping practices decline. Setting aside time to regularly inspect the workplace for hazards can help identify shortcomings so that they can be addressed before an incident occurs.

How to accomplish it

- Conduct regular inspections of all operations, equipment, work areas and facilities. Have workers participate on the inspection team and talk to them about hazards that they see or report.
- Be sure to document inspections so you can later verify that hazardous conditions are corrected. Take photos or video of problem areas to facilitate later discussion and brainstorming about how to control them, and for use as learning aids.
- Include all areas and activities in these inspections, such as storage and warehousing, facility and equipment maintenance, purchasing and office functions, and the activities of on-site contractors, subcontractors, and temporary employees.
- Regularly inspect both plant vehicles (e.g., forklifts, powered industrial trucks) and transportation vehicles (e.g., cars, trucks).

- Use checklists that highlight things to look for. Typical hazards fall into several major categories, such as those listed below; each workplace will have its own list:
  - ✓ General housekeeping
  - ✓ Slip, trip, and fall hazards
  - ✓ Electrical hazards
  - ✓ Equipment operation
  - ✓ Equipment maintenance
  - ✓ Fire protection
  - ✓ Work organization and process flow (including staffing and scheduling)
  - ✓ Work practices
  - ✓ Workplace violence
  - ✓ Ergonomic problems
  - ✓ Lack of emergency procedures
  - ✓ Before changing operations, workstations, or workflow; making major organizational changes; or introducing new equipment, materials, or processes, seek the input of workers and evaluate the planned changes for potential hazards and related risks.

Note: Many hazards can be identified using common knowledge and available tools. For example, you can easily identify and correct hazards associated with broken stair rails and frayed electrical cords. Workers can be a very useful internal resource, especially if they are trained in how to identify and assess risks.

Action item 3: Identify health hazards

Identifying workers' exposure to health hazards is typically more complex than identifying physical safety hazards. For example, gases and vapors may be invisible, often have no odor, and may not have an immediately noticeable harmful health effect. Health hazards include chemical hazards (solvents, adhesives, paints, toxic dusts, etc.), physical hazards (noise, radiation, heat, etc.), biological hazards (infectious diseases), and ergonomic risk factors (heavy lifting, repetitive motions, vibration). Reviewing workers'

medical records (appropriately redacted to ensure patient/worker privacy) can be useful in identifying health hazards associated with workplace exposures.

How to accomplish it

- Identify chemical hazards –review SDS and product labels to identify chemicals in your workplace that have low exposure limits, are highly volatile, or are used in large quantities or in unventilated spaces. Identify activities that may result in skin exposure to chemicals.
- Identify physical hazards –identify any exposures to excessive noise (areas where you must raise your voice to be heard by others), elevated heat (indoor and outdoor), or sources of radiation (radioactive materials, X-rays, or radiofrequency radiation).
- Identify biological hazards –determine whether workers may be exposed to sources of infectious diseases, molds, toxic or poisonous plants, or animal materials (fur or scat) capable of causing allergic reactions or occupational asthma.
- Identify ergonomic risk factors –examine work activities that require heavy lifting, work above shoulder height, repetitive motions, or tasks with significant vibration.
- Conduct quantitative exposure assessments –when possible, using air sampling or direct reading instruments.
- Review medical records –to identify cases of musculoskeletal injuries, skin irritation or dermatitis, hearing loss, or lung disease that may be related to workplace exposures.

Note: Identifying and assessing health hazards may require specialized knowledge. Small businesses can obtain free and confidential occupational safety and health advice services, including help identifying and assessing workplace hazards, through OSHA's On-site Consultation Program.

Action item 4: Conduct incident investigations

Workplace incidents –including injuries, illnesses, close calls/near misses, and reports of other concerns– provide a clear indication of where hazards exist. By thoroughly investigating incidents and reports, you will identify hazards that are likely to cause future harm. The purpose of an investigation must always be to identify the root causes (and there is often more than one) of the incident or concern, in order to prevent future occurrences.

How to accomplish it

- Develop a clear plan and procedure for conducting incident investigations, so that an investigation can begin immediately when an incident occurs. The plan should cover items such as:
  - ✓ Who will be involved
  - ✓ Lines of communication
  - ✓ Materials, equipment, and supplies needed
  - ✓ Reporting forms and templates
- Train investigative teams on incident investigation techniques, emphasizing objectivity and open-mindedness throughout the investigation process.
- Conduct investigations with a trained team that includes representatives of both management and workers.
- Investigate close calls/near misses.
- Identify and analyse root causes to address underlying program shortcomings that allowed the incidents to happen.
- Communicate the results of the investigation to managers, supervisors, and workers to prevent recurrence.

Action item 5: Identify hazards associated with emergency and non-routine situations

Emergencies present hazards that need to be recognized and understood. Non routine or infrequent tasks, including maintenance and startup/shutdown activities, also present potential hazards. Plans and procedures need to be developed for responding

appropriately and safely to hazards associated with foreseeable emergency scenarios and non-routine situations.

How to accomplish it

- Identify foreseeable emergency scenarios and non-routine tasks, taking into account the types of material and equipment in use and the location within the facility. Scenarios such as the following may be foreseeable:
  - ✓ Fires and explosions
  - ✓ Chemical releases
  - ✓ Hazardous material spills
  - ✓ Start-ups after planned or unplanned equipment shutdowns
  - ✓ Non routine tasks, such as infrequently performed maintenance activities
  - ✓ Structural collapse
  - ✓ Disease outbreaks
  - ✓ Weather emergencies and natural disasters
  - ✓ Medical emergencies
  - ✓ Workplace violence

Action item 6: Characterize the nature of identified hazards, identify interim control measures, and prioritize the hazards for control

The next step is to assess and understand the hazards identified and the types of incidents that could result from worker exposure to those hazards. This information can be used to develop interim controls and to prioritize hazards for permanent control.

How to accomplish it

- Evaluate each hazard by considering the severity of potential outcomes, the likelihood that an event or exposure will occur, and the number of workers who might be exposed.
- Use interim control measures to protect workers until more permanent solutions can be implemented.

- Prioritize the hazards so that those presenting the greatest risk are addressed first. Note, however, that employers have an on-going obligation to control all serious recognized hazards and to protect workers.

Note: "Risk" is the product of hazard and exposure. Thus, risk can be reduced by controlling or eliminating the hazard or by reducing workers' exposure to hazards. An assessment of risk helps employers understand hazards in the context of their own workplace and prioritize hazards for permanent control.

Self-Check - 3	Written Test

Instruction: Follow the below selected instruction

The following are true or false items, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	Safety hazards are unsafe working conditions that that can cause injury, illness, and death
	True or false:
2	physical hazards include viruses, bacteria, insects, animals, etc., that can cause adverse health impacts
	True or false:
3	Biological hazards the most common workplace hazards, including vibration, noise and slips, trips and falls;
	True or false:

Note: Satisfactory rating - 2 points **Unsatisfactory - below 2 points**

Information Sheet- 4	Controlling and determining scenarios documents

4.1 Introduction

A controlled document is a document that must undergo formal review, formal approval, controlled distribution, controlled modification and controlled storage and access. Or, in other words, a controlled document is a document that goes through Document Control processes.

- **Standard documents requires for quality control:**
  - ✓ Quality Manual.
  - ✓ Quality Policy.
  - ✓ Quality Objectives.
  - ✓ Quality Records.
  - ✓ Control of Documents
  - ✓ Control of Records
  - ✓ Internal Audit
  - ✓ Control of Nonconforming Product
  - ✓ Corrective Action
  - ✓ Preventive Action

Document control is all to do with transferring information between relevant parties. This could be a law firm sending a report to a client, a construction firm receiving technical drawings from a designer, or a bakery giving an employee a recipe to follow.

4.2 Document controls and how they can be applied

Document control specialists are responsible for managing company documents while also ensuring their accuracy, quality and integrity. These specialists' help companies adhere to record retention policies, safeguard information and retrieve data more effectively.

- **To approve documents for adequacy prior to issue**
  - ✓ Once a document has been drafted, it will often go through a process of review and approval where it is read, commented on and amendments made where necessary prior to its release.
  - ✓ Depending on the type and importance of the document, it could just require approval by one person.
  - ✓ Often, companies will have space on the front page of a document for certain authorized people to sign off the document as approved. This can either be done as hard copy or using digital signatures.

What constitutes Good Documentation?

- ➢ Approve, review and update documents
- ➢ Changes & current revision status of documents identified
- ➢ Relevant versions of applicable documents available at points of use
- ➢ Documents remain legible and readily identifiable
- ➢ Documents of external origin identified and their distribution controlled
- ➢ Prevent unintended use of obsolete documents, and archiving.

- **To review and update as necessary and re-approve documents**
  - ✓ Whilst not a requirement, most organisations should review documents once annually or during periods of significant organisational change.
  - ✓ Reviewing a document does not mean it has to be revised—if it is still fit for purpose and no changes need to be made, it can stay at its current revision.
  - ✓ To protect from unauthorised editing, Word documents can be password protected or locked to only allow certain changes (e.g. comments or tracked changes). It is also common for organisations to only share PDF or printed

versions of documents with anyone except the document controller and authorised reviewer/approver.

- **To ensure that changes and the current revision status of documents are identified**
  - ✓ The revision number of a document is usually shown on the title page, but an extra tip would be to include it in the header or footer of every page. This ensures that if the document is printed, it cannot be mixed up with parts of a superseded document.
  - ✓ A table showing the revision history of a document is very useful. Against each revision number and date, the reviewer can draw attention to anything that has been added, amended or removed since the previous revision.
  - ✓ If a document has very specific alterations made to it when revised, the reviewer may wish to highlight these throughout the document.

- **To ensure that relevant versions of applicable documents are available at points of use**
  - ✓ The document controller is usually the one person who holds the master copies of every document. Nowadays this is mostly done electronically, and as such it is imperative that a backup regime is in place to avoid losing any documentation.
  - ✓ If an onsite back up (e.g. onto a hard drive) or hard copies of master documents are kept, it's advised that these are held in a fireproof cabinet so they are kept safe.
  - ✓ Notification of document changes is dependent on the way the organisation manages its distribution of documents. Some document controllers might keep a register showing who has been given controlled copies of certain documents, whilst some might use an online system with email distribution to a specific mailing list etc.

- **To ensure that documents remain legible and readily identifiable**
  - ✓ A document reference system can be really useful for identifying documents easily. A document number can be as simple or as detailed as the organization requires, but a code that includes reference codes to projects, clients, departments or work sites can be really useful.
  - ✓ E.g. a document numbered MAN-DES-PRO-001 could mean it belongs to the Manchester Office, Design Department, Procedure no. 001, or J12-LET-034 could mean it's the 34th letter written to customer J12.
  - ✓ It is up to the organization to decide what format the documents should take. See section B regarding electronic copies and unauthorized editing.

- **To ensure that documents of external origin determined by the organization to be necessary for the planning and operation of the quality management system are identified and their distribution controlled**
  - ✓ Some organizations use specialist subcontractors who will produce their own procedures to follow. To ensure the distribution of these external procedures is controlled, the organization should control the documents in the same way as the documents they produce are controlled.
  - ✓ An example of an organization reviewing external documents could be a client/designer providing the organization with technical drawings, but before they are used an engineer must check them to ensure suitability and highlight any potential issues.

- **To prevent the unintended use of obsolete documents, and to apply suitable identification to them if they are retained for any purpose**
  - ✓ This goes back to section D and notification of document changes.
  - ✓ What happens to superseded or obsolete documents depends on how they are used within the organization. Some document controllers will collect hard copy documents from those who they have been issued to, to ensure that they are all out of circulation and can be destroyed.

- ✓ It is wise for the document controller to keep a folder (either electronic or hard copy) of superseded documents for future reference, but they should be clearly marked as superseded either by using a stamp or watermark

Observations on poor documentation practices

- Document error correction not signed/dated, and didn't include a reason for the correction
- Write-overs, multiple line-through and use of "White-out" or other masking device
- Sample sequence table and audit trail not documented (*if its not documented, it didn't happen*)
- SOP related to production, calibration, storage and maintenance not authorized by the QA head
- The delegation for the batch release, in case of absence of the QA manager, not recorded / documented
- Out-of-specification (OOS) procedure not detailed enough; flow chart and /or check-list not available.

Self-Check - 4	Written Test

Instruction: Follow the below selected instruction

The following are true or false items, write true if the statement is true and write false if **the statement is false.**

N°	Questions and answers
1	A controlled document is a document that goes through Document Control processes
	True or false:
2	A document reference system can be really useful for identifying documents easily
	True or false:
3	Notification of document changes is dependent on the way the organisation manages its distribution of documents.
	True or false:

Note: Satisfactory rating - 2 points **Unsatisfactory - below 2 points**

Information Sheet 5	Documenting agreement for the control scenarios

5.1 Documenting agreement for the control scenarios

- **Documentation**

The commissioning documentation should include the following:

- ✓ Specification, including cooling capacity, operating conditions and limits
- ✓ Refrigeration and electrical circuit diagrams
- ✓ Refrigerant charge and operation conditions
- ✓ Set points for all the controls and safety devices
- ✓ Commissioning and operating information for all major components
- ✓ Site tests performed such as pressure, tightness, vacuum and electrical insulation tests
- ✓ For larger systems, sub-system controls done by different sub-contractors for running currents, flows and pressure drops.

- **Initial Checks**

The installation should be initially checked to ensure that it is in accordance with the specified design. For example, components are those specified, electrical equipment is suitable for the pressures and temperatures, pipework correctly installed and adequately supported, cleanliness of heat exchangers, water circuits and filters, compressor mountings correctly installed, safety and pressure controls correctly connected, non-return and pressure regulating valves correctly positioned, correct wiring and control sequence.

- **Pre-set Controls**

The next stage is to preset as many controls and protection devices as possible. Only after all possible static checks and adjustments have been made to the system should it be started for the first time. These precautions will prevent most of the common types of failure occurring during the initial running period. Typically settings include service shut-off valves open, water controls set, control switches preset as accurately as possible,

temperature control and cut-outs set. Also compressor rotational direction checked and defrosts timers set.

- **Operational Checks**

Start pumps and fans without refrigeration machinery and evaluate flows from available indications such as flow meters, pressure differences over pumps, fans, filters depending on what is available and check for air in water/brine systems. For secondary systems with freeze protection, it must be ensured that they are free of air before the temperature is lowered and the systems are left to operate for longer periods. Air in these systems can be virtually impossible to remove if the gas is distributed as micro bubbles in the system due to operation without proper degassing. This will affect the performance of the system during tests and operation.

- **Performance Check**

In the final commissioning stage, readings are taken and recorded and compared with the specification and design figures. Some final adjustments to airflows, secondary fluid flows, etc. may be necessary. The following measurements, as applicable, should be considered as the absolute minimum to be taken and recorded:

- ✓ Ambient conditions, dry and wet bulb
- ✓ Refrigerant pressures and temperatures at expansion valve inlet, evaporator outlet, and compressor suction and discharge
- ✓ Secondary fluid temperatures at heat exchanger inlet and outlets
- ✓ Pump, fan and filter pressures
- ✓ Settings of all adjustable controls
- ✓ Electric motor currents

- **Hand Over**

A complete set of plant documentation and commissioning records should be left on site for future reference. These should include the following:

- ✓ A copy of the commissioning log
- ✓ Flow, control, electrical and layout diagram and drawings

- ✓ The system refrigerant type, and charge; and oil type and oil charge
- ✓ Operating instructions
- ✓ Maintenance instructions
- ✓ Copies of instructions and manuals for all proprietary items of equipment
- ✓ A list of recommended spare parts
- ✓ Declaration of conformity and any other information as required to complete the health and safety file
- ✓ The following is a checklist guide to commissioning activities and documentation provided by the U.S. Department of Energy—Energy Efficiency and Renewable Energy:
- ✓ Owner's requirements: List and describe the owner's requirements with performance criteria.
- ✓ Commissioning plan: This should be created as early in the design phase as possible including the management strategy and list of all features and systems to be commissioned.
- ✓ Bid documents: Integrate commissioning requirements in the construction bid and contract documents.
- ✓ Functional performance test procedures and checklists: Develop functional performance test procedures or performance criteria verification checklists for each of the elements identified in the commissioning plan.
- ✓ Commissioning report: Complete a final commissioning report and submitted to the Owner. The commissioning report should summarize all the tasks, findings, and documentation of the commissioning process and will address the actual performance of the building systems in reference to the design documents.
- ✓ Training: Assemble written verification that training was conducted for appropriate personnel on all commissioned features and systems.
- ✓ Operation and maintenance manuals: Review operation and maintenance manuals for completeness including instructions for installation, maintenance, replacement, and start-up; replacement sources; parts list; special tools; performance data; and warranty details.
- ✓ Decommissioning (Re Cx) management manual: Develop an indexed Re Cx management manual with components such as guidelines for establishing and

tracking benchmarks for whole-building energy use and equipment efficiencies; recommendations for recalibration frequency of sensors; list of all user adjustable set-points and reset schedules; and list of diagnostic tools.

- ✓ Acceptance Phase: While this is not strictly a separate phase of the building delivery process, it is during this period that the facility and its systems and equipment are inspected, tested, verified, and accepted.

- **Some principal features of the post-commissioning documentation are:**
  - ✓ Modification records;
  - ✓ Equipment examination records:
    - ➢ pressure vessels,
    - ➢ pressure piping,
    - ➢ protective devices;
    - ✓ Equipment test records:
    - ➢ pressure and leak tests,
    - ➢ pressure relief valve tests,
    - ➢ rotating machinery tests,
    - ➢ instrument tests,
    - ➢ computer system tests;
  - ✓ Computer records;
  - ✓ Spare inventories;
  - ✓ Safety reviews records:
    - ➢ HAZOP follow-up,
    - ➢ safety audits;
  - ✓ Environmental review records;
  - ✓ Reservation list.

- **Commissioning Phase Three – Close-Out**

As the team returns to normal day working after weeks of intensive commissioning periods in the field, followed potentially by shift-working activities leading the operations team in the start-up of the new asset, some commissioning procedures may have been

left incomplete and not completely signed off, although the procedure has actually been executed. A trawl through all commissioning documentation now needs to be conducted, all documents brought up-to-date before finally passing to the client and/or operations group for archiving.

- **Commissioning Phase One – Prepare**

Function: Responsible for the execution of all commissioning activities, input as required into systemization and system planning, direct and or execute pre-commissioning, leak testing, introduction of chemicals, commissioning, start-up and validation testing of the allocated systems; assist as required with loop, motor and interlock checking.

Typical duties: Organize and execute all commissioning activities within responsible systems Input into systemization of the plant Create all commissioning documentation and check sheets for assigned systems If required prepare Standard Operating Procedures If required prepare and deliver training package Punch list allocated systems

Self-Check - 5	Written Test

Instruction: Follow the below selected instruction

Answer all the questions listed below. Use the Answer sheet provided in the next page:

N°	Questions and answers
1	The commissioning report should summarize all the tasks, findings, and documentation of the commissioning process.
	True or false:
2	A complete set of plant documentation and commissioning records should be not left on site for future reference.
	True or false:
3	Acceptance Phase is not strictly a separate phase of the building delivery process,
	True or false

Note: Satisfactory rating - 2points Unsatisfactory - below 2 points

Information Sheet 6	lishing schematic arrangement for controlling circuit

6.1 Establishing schematic arrangement for controlling circuit

Circuit control devices are used everywhere that electrical or electronic circuits are used. They are found in submarines, computers, aircraft, televisions, ships, space vehicles, medical instruments, and many other places. In this chapter you will learn what circuit control devices are, how they are used, and some of their characteristics.

Circuit control, in its simplest form, is the application and removal of power. This can also be expressed as turning a circuit on and off or opening and closing a circuit. Before you learn about the types of circuit control devices, you should know why circuit control is needed. If a circuit develops problems that could damage the equipment or endanger personnel, it should be possible to remove the power from that circuit. The circuit protection devices discussed in the last chapter will remove power automatically if current or temperature increase enough to cause the circuit protection device to act. Even with this protection, a manual means of control is needed to allow you to remove power from the circuit before the protection device acts. When you work on a circuit, you often need to remove power from it to connect test equipment or to remove and replace components. When you remove power from a circuit so that you can work on it, be

- **Types of circuit control devices**

Circuit control devices have many different shapes and sizes, but most circuit control devices are switches, solenoids, or relays

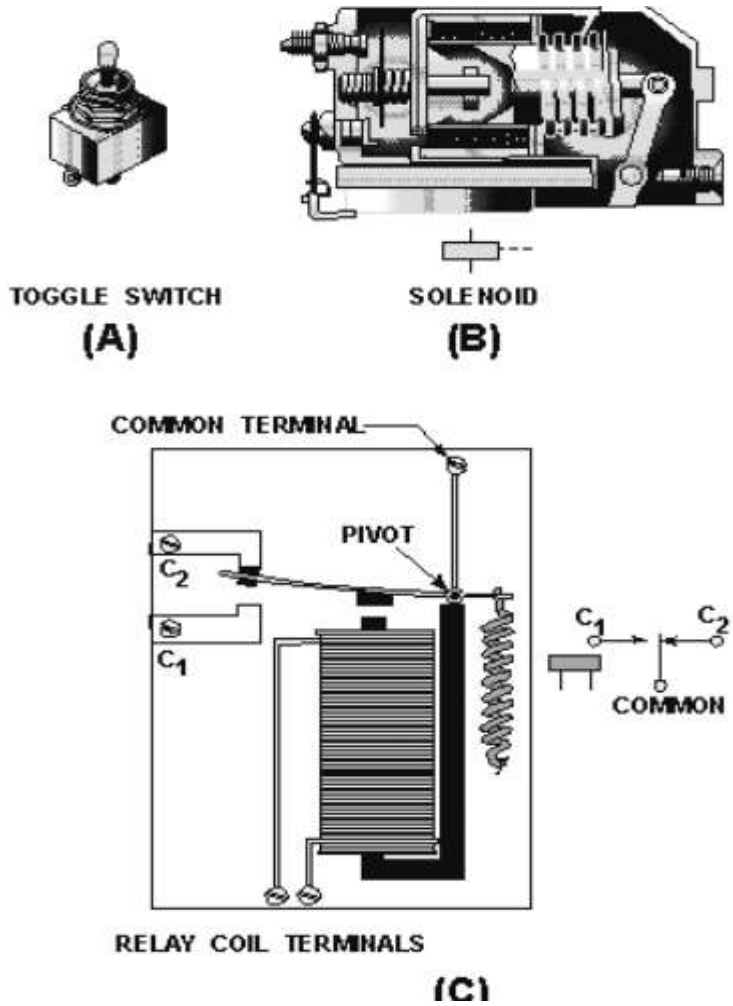


Figure 5: Typical circuit control devices: relay coil terminals

Figure 6 views A, is a simple toggle switch and the schematic symbol for this switch is shown below it. Figure 6views B, is a cutaway view of a solenoid. The schematic symbol below the solenoid is one of the schematic symbols used for this solenoid. Figure 6views C, shows a simple relay. One of the schematic symbols for this relay is shown next to the relay

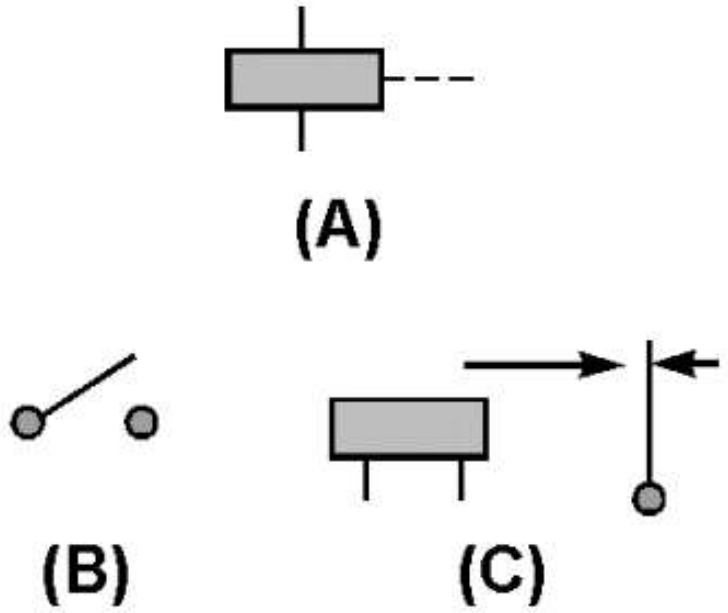


Figure 6: Systematic symbol recognition

- **Switch Types**

There are thousands and thousands of switch applications found in home, industry, and the Navy. Hundreds of electrical switches work for you every day to perform functions you take for granted. Some switches operate by the touch of a finger and many others are operated automatically.

Switches are used in the home to turn off the alarm clock, to control the stove, to turn on the refrigerator light, to turn on and control radios and televisions, hair dryers, dishwashers, garbage disposals, washers and dryers, as well as to control heating and air conditioning. A typical luxury automobile with power seats and windows might have as many as 45 switches.

- **Manual Switches**

Manual switch is a switch that is controlled by a person. In other words, a manual switch is a switch that you turn on or off. Examples of common manual switches are a light switch, the ignition switch on a motor vehicle, or the channel selector on a television. You may not think of the channel selector as a switch that you use to turn something on or

off, but that is what it does. The channel selector is used to turn on the proper circuit and allows the television to receive the channel you have selected.

- **Automatic Switch**

An automatic switch is a switch that is controlled by a mechanical or electrical device. You do not have to turn an automatic switch on or off. Two examples of automatic switches are a thermostat and the distributor in a motor vehicle. The thermostat will turn a furnace or air conditioner on or off by responding to the temperature in a room. The distributor electrically turns on the spark plug circuit at the proper time by responding to the mechanical rotation of a shaft. Even the switch that turns on the light in a refrigerator when the door is opened is an automatic switch.

- **Multi contact Switches**

Switches are sometimes used to control more than one circuit or to select one of several possible circuits. An example of a switch controlling more than one circuit is the AM/FM selector on a radio. This switch enables you to control either the AM or FM portion of the radio with a single switch. An example of a switch that selects one of several circuits is the channel selector of a television set.

- **Number of Poles and Number of Throws**

Multi contact switches (other than rotary switches, which will be covered later) are usually classified by the number of POLES and number of THROWS. Poles are shown in schematics as those contacts through which current enters the switch; they are connected to the movable contacts. Each pole may be connected to another part of the circuit through the switch by "throwing" the switch (movable contacts) to another position.

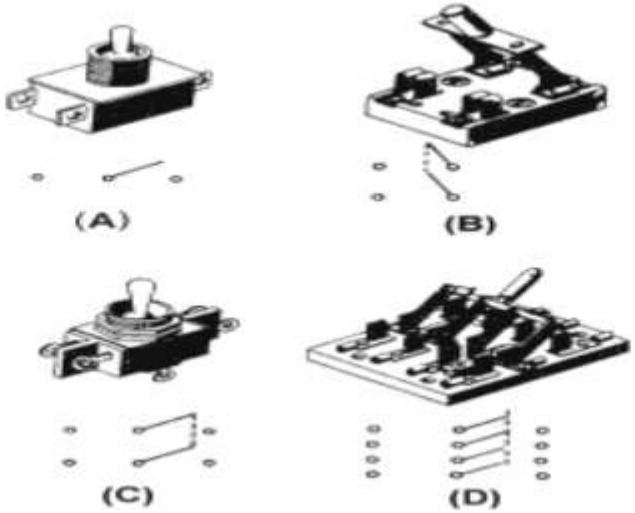


Figure 7 Multi contact switches.

Figure 8 (A) shows a single-pole, double-throw switch. The illustration shows three terminals (connections) on this switch. The schematic symbol for the switch is also shown. The centre connection of the schematic symbol represents the point at which current enters the switch. The left and right connections represent the two different points to which this current can be switched. From the schematic symbol, it is easy to determine that this is a single-pole, double-throw switch. Now look at figure 8 (B).

The switch is shown with its schematic symbol. The schematic symbol has two points at which current can enter the switch, so this is a double-pole switch. Each of the poles is mechanically connected (still electrically separate) to one point, so this is a single-throw switch. Only one throw is required to route two separate circuit paths through the switch. Figure 8 (C) shows a double-pole, double-throw switch and its schematic symbol. Figure 8 (D) shows a four-pole, double-throw switch and its schematic symbol. It might help you to think of switches with more than one pole as several switches connected together mechanically. For example, the knife switch shown in figure 8 (D) could be thought of as four single-pole, double-throw switches mechanically connected together.

- **Single-Break and Double-Break Switches**

Switches can also be classified as SINGLE-BREAK or DOUBLE-BREAK switches. This refers to the number of places in which the switch opens or breaks the circuit. All of the

switches shown so far have been single-break switches. A double-break switch is shown in figure 9. The schematic symbol showed in figure 9(A) shows that this switch breaks the circuit in two places (at both terminals). The upper part of the schematic symbol indicates that these contacts are in the open position and the circuit will close when the switch is acted upon (manually or automatically). The lower symbol shows closed contacts. These contacts will open the circuit when the switch is acted upon

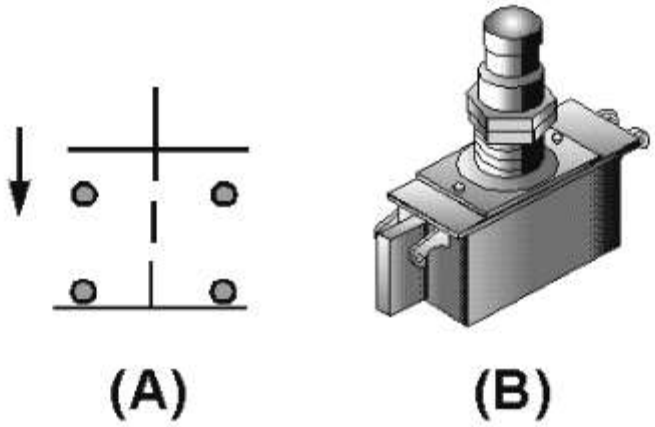


Figure 8: Double-break pushbutton switch

Figure 9(B) is a picture of the switch. This switch is called a pushbutton switch because it has a button that must be pushed to change the switch contact connections. Notice that the switch has four terminals. The number of poles in a switch is independent of the number of throws and whether it is a single or double break switch. The number of throws in a switch is independent of the number of poles and whether it is a single or double break switch. In other words, each characteristic of a switch (poles, throws, break) is not determined by either of the other characteristics

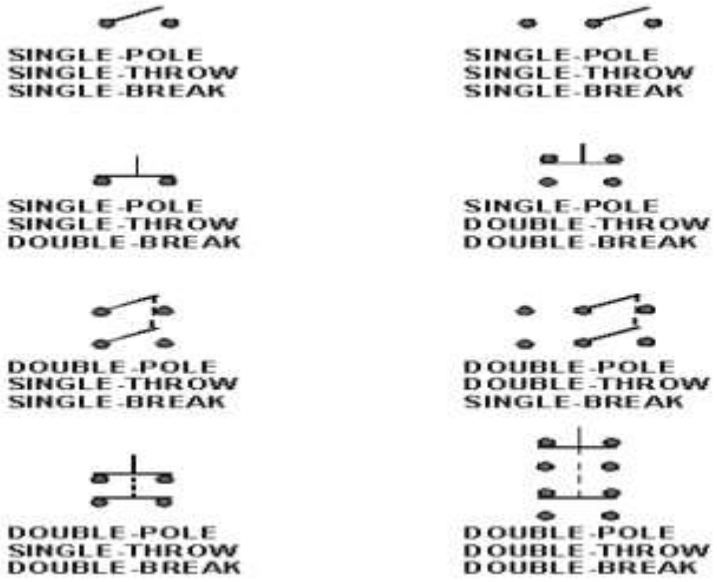


Figure 9: Schematic symbols of switch configurations.

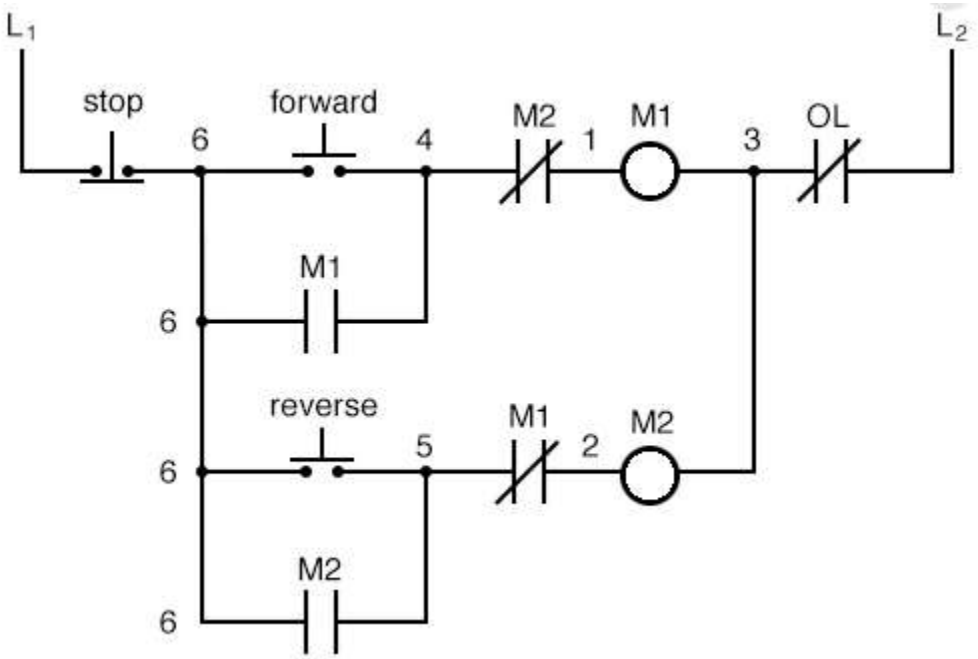


Figure 10: Motor Control Circuits | Ladder Logic | Electronics Textbook

Preventive maintenance of switches

As already mentioned, switches do not fail very often. However, there is a need for preventive maintenance of switches. Periodically switches should be checked for corrosion at the terminals, smooth and correct operation, and physical damage. Any problems found should be corrected immediately. Most switches can be inspected visually for corrosion or damage. The operation of the switch may be checked by moving the actuator. When the actuator is moved, you can feel whether the switch operation is smooth or seems to have a great deal of friction. To check the actual switching, you can observe the operation of the equipment or check the switch with a mete

Self-Check - 6	Written Test

Instruction: Follow the below selected instruction

Answer all the questions listed below. Use the Answer sheet provided in the next page:

N°	Questions and answers
1	Circuit control, in its simplest form, is the application and removal of power.
	True or false:
2	Automatic switch is a switch that is controlled by a person. In other words, a manual switch is a switch that you turn on or off.
	True or false:
3	The number of poles in a switch is independent of the number of throws and whether it is a single or double break switch.
	True or false

Note: Satisfactory rating - 2 points **Unsatisfactory - below 2 points**

Information Sheet 7	Obtaining and establishing materials needed to connect circuit

7.1 Obtaining and establishing materials needed to connect circuit

How to make a circuit? A circuit is a path that electricity flows along. It starts at a power source, like a battery, and flows through a wire to a light bulb or other object and back to other side of the power source. You can build your own circuit and see how it works with this project!

What You Need:

- Flashlight (one you can take apart)
- Batteries for your flashlight
- Three pieces of wire that can be cut and stripped (See Procedure for more information.)
- Ruler with metric measurements
- Electrical tape (and/or rubber bands)
- Scissors or knife (and an adult's help)
- Assortment of metal and non-metal household materials that can be tested in your circuit
- Bulb holder (optional)
- Battery holders (optional**)

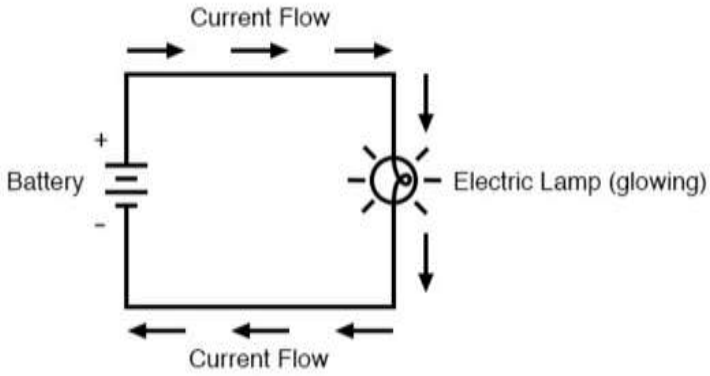


Figure 11: simple electrical circuit

Part 1 – Making a Circuit:

- Connect one end of each wire to the screws on the base of the light bulb holder. (If you're using foil, ask an adult to help you unscrew each screw enough to fit a foil strip under it.)
- Connect the free end of one wire to the negative ("-") end of one battery. Does anything happen?
- Attach the free end of the other wire to the positive ("+") end of the battery. Now what happens?

Part 2 – Adding Power

- Disconnect the battery from your circuit. Stand one battery so that the "+" end is pointing up, then set the other battery next to it so that the flat "-" end is pointing up. Tape around the middle of the batteries to hold them together.
- Set a paperclip across the batteries so that it connects the "+" end of one to the "-" end of the other. Tape the paperclip in place with a narrow piece of tape (do not tape over the metal battery ends).
- Turn the batteries over and tape one end of a paper clip onto each of the batteries. Now you can connect one wire to each paper clip. (The bottom of the battery pack should only have one paper clip – do not connect a wire to it.)
- Connect the free ends of the wires to the light bulb.
- (Note: Instead of steps 1-3, you can use two batteries in battery holders and connect them together with one wire.)
- **Caution:** Electricity from wall outlets is very dangerous and can be deadly. Never cut into a wire or open an electronic device while it is plugged into a wall outlet.

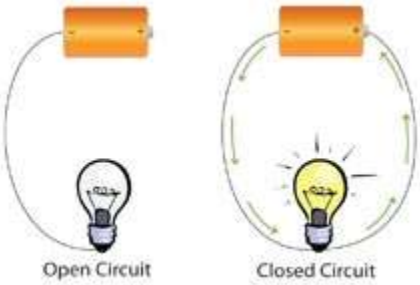


Figure 12: open & close circuits

In the first part, you learned how to make a circuit with a battery to light up a light bulb. Batteries supply electricity. When they're connected properly, they can "power" things, like a flashlight, an alarm clock, a radio even a robot! Why didn't the light bulb light up when you connected it to one end of the battery with a wire? Electricity from a battery has to flow out one end (the negative or "-" end) and back in through the positive ("+") end in order to work.

What you built with the battery, wire, and bulb in step 3 is called an **open circuit**.
In order for electricity to start flowing, you need a **closed circuit**. Electricity is caused by tiny particles with negative charges, called **electrons**.

- Insulator or Conductor

Materials that electricity can flow through are call conductors. Materials that stop electricity from flowing are called insulators.
You can find out which things around your house are conductors and which are insulators using the circuit you made in the last project to test them!

What You Need:

- Circuit with light bulb & 2 batteries
- Extra alligator clip wire (or aluminium foil wire*)
- Objects to test (made of metal, glass, paper, wood, and plastic)
- Worksheet (optional)
- What You Do:
- Disconnect one of the wires from the battery pack. Connect one end of the new wire to the battery. You should have two wires with free ends (between the light bulb and the battery pack).
- You have made an open circuit and the bulb should not light up. Next you will test objects to see if they are conductors or insulators. If the object is a conductor, the light bulb will light up. It is is an insulator, it will not light. For each object, guess whether you think each object will complete the circuit and light up the light bulb or not.

- Connect the ends of the free wires to an object and see what happens. Some objects you could test are a paper clip, a pair of scissors (try the blades and the handles separately), a glass, a plastic dish, a wooden block, your favourite toy, or anything else you can think of.

Before you test each object, guess whether it will make the light bulb light up or not. If it does, the object you're touching the wires to is a conductor. The light bulb lights up because the conductor completes, or closes, the circuit and electricity can flow from the battery to the light bulb and back to the battery! If it doesn't light up, the object is an insulator and it stops the flow of electricity, just like an open circuit does. Most other materials, like plastic, wood, and glass are insulators. An insulator in an open circuit does not complete the circuit, because electrons cannot flow through it! The light bulb did not light up when you put an insulator in between the wires.

If you're using wires or alligator clips, take a good look at them. Inside they are made of metal, but they have plastic around the outside. Metal is a good conductor. Plastic is a good insulator. The plastic wrapped around the wire helps keep electrons flowing along the metal wire by blocking them from transferring to other object outside of the wires.

Self-Check - 7	Written Test

Instruction: Follow the below selected instruction

Answer all the questions listed below. Use the Answer sheet provided in the next page:

N°	Questions and answers
1	When a circuit is complete, or closed, electrons can flow from one end of a battery all the way around, through the wires, to the other end of the battery.
	True or false:
2	Electricity from wall outlets is very dangerous and can be deadly. Never cut into a wire or open an electronic device while it is plugged into a wall outlet.
	True or false:
3	The materials, like plastic, wood, and glass are conductors .
	True or false

Note: Satisfactory rating - 2 points **Unsatisfactory - below 2 points**

8.1 Obtaining tools and equipment to connect control circuits

- **Screwdrivers**

For every screw type there is a screwdriver. For most tasks, a basic selection of screwdrivers, such as the ones shown in Figure1-1, is all you'll need.

Figure 13: Screwdrivers

Combination driver sets are available that use a common handle and a selection of driver bits. a set with slotted, Phillips, hex, Y, and other styles.

Figure 14: Combination driver set

- **Pliers**

The pliers available from a hardware store or other locations are acceptable for many tasks, but they are not always ideal for working with electronics**.**

Figure 15: Selection of various common pliers

- **Wire Strippers**

Trying to strip the insulation from wire using something like a pair of flush or diagonal cutters is risky, at best. Unless you are very, very good, there is a distinct possibility that the wire will be nicked, and when that happens, the nicked spot can cause the wire to break.

Figure 16: Simple manual wire strippers & Automatic wire stripp

- **Crimping Tools**

If you are working with connectors that utilize crimped terminals, then a crimping tool is essential. There really is no other way to make a good connection with these types of connectors. Rectangular connectors that use insert able socket terminals are readily available, and they come in a variety of styles and sizes.

Figure 17: A crimping tool for small contacts

- Rotary tool
- A rotary tool is extremely useful for cutting small square holes in a plastic box, trimming a slightly oversized printed circuit board to fit into an enclosure, drilling holes in a PCB, and performing other tasks that require a small tool with a lot of attachment options.
- Drills
- Electric hand drills are useful for a lot of things, but drilling a precise hole typically isn't one of those things. A small drill press is essential for drilling holes for screws, switches, LED indicators, or connectors
- Small Hand Saws
- A small saw is useful for cutting things like tubing and sections of sheet materials. Specialty saws, such as a jeweler's saw, are extremely useful for creating odd-shaped holes in things.
- Soldering Tools
- A decent soldering iron or a soldering station is absolutely essential for working with electronics. Avoid the cheap soldering irons, as they won't hold up to heavy use and they don't hold their tip temperature reliably.

A good set of tools can make all the difference between success and failure, but knowing how to use them and gaining experience is the other key ingredient. In not available, we will look at some of the techniques used with various tools.

Warning:

Some of the tools described in this chapter can severely injure you if used incorrectly or carelessly. Always wear safety glasses when working with power tools, and always read and follow the manufacturer's safety precautions provided with the tool.

Self-Check - 8	Written Test

Instruction: Follow the below selected instruction

Answer all the questions listed below. Use the Answer sheet provided in the next page:

N°	Questions and answers	
1	The essential tool for working with connectors that utilize crimped terminals is	
	A. Crimping Tools	C. Pliers
	B. Wire Strippers	D. rotary tool
2	Is useful for cutting things like tubing and sections of sheet materials.	
	A. Soldering Tools	C. Drills
	B. Small Hand Saws	D. screw driver
3	Used to strip the insulation from wire using something like a pair of flush or diagonal cutters is risky, at best	
	A. Crimping Tools	C. Pliers
	B. Wire Strippers	D. rotary tool

Note: Satisfactory rating - 2 points Unsatisfactory - below 2 points

Information Sheet - 9	Checking procedures for correct operation and safety

9.1 Checking procedures for correct operation and safety

Most injuries involving electricity could have been prevented if unsafe equipment had been taken out of service or if unsafe work areas and work practices did not exist. To minimize the risk of injury from electrical sources, it is necessary to assure that electrical "sources" are properly insulated and grounded, that circuit-protecting devices are utilized, and that safe work practices are followed.

- **Procedures:**

The required training and work procedures include but are not limited to:

- ✓ De-energized parts
- ✓ Verification of de- energization
- ✓ Re- energization
- ✓ Distinguish live parts from other parts
- ✓ Work on or near overhead power lines
- ✓ Portable ladders
- ✓ Conductive apparel
- ✓ Housekeeping duties
- ✓ Electrical safety interlocks
- ✓ Lockout/tag out
- ✓ Cord and plug connected equipment
- ✓ Eye and face protection
- ✓ Safe clearance distances for voltages, and
- ✓ Insulated tools.

- **Responsibility:**

Each department is responsible for complying with this section. Electrical safety-related work practices apply to:

Qualified persons - those familiar with the construction and operation of electrical equipment, and the hazards involved and who have training in avoiding the electrical hazards of working on or near energized parts;

Unqualified persons - those with little or no such training working on, near or with the following installations:

- ✓ Premises Wiring: Installations of electric conductors and equipment within or on buildings or other structures, and on other premises such as yards, parking lots, other lots, and industrial substations.
- ✓ Wiring for connection to supply: Installations of conductors that connect to the supply of electricity.
- ✓ Other Wiring: Installations of other outside conductors on the premises.
- ✓ Optical Fiber Cable: Installation of optical fiber cable where such are made along with electric conductors.

- **Other work covered by unqualified persons includes work on, near or with:**
  - ✓ Generation, transmission, and distribution installations
  - ✓ Communications installations
  - ✓ Installations in vehicles
  - ✓ Railway installations

- **Safe working practices:**
  - ✓ Electrical cords must be inspected for frays, cracks, exposed wires, and to ensure that the insulating jacket is intact. Check the plug and cord for defects, and replace or repair prior to further use.
  - ✓ Electrical cords must not come in contact with heat sources such as pipes or radiators, hazardous substances, or sharp objects and must not be run through water.
  - ✓ Equipment must not be placed where the electrical connection could be hit, tripped over, or walked on.
  - ✓ Extension cords shall not be used as a permanent source of wiring.

- ✓ Electrical utility rooms containing circuit breakers shall not be blocked with equipment, clutter, etc. Equipment/articles should not be placed within three feet of a circuit breaker.
- ✓ Employees should know the location of circuit breakers in their work area.
- ✓ Circuit breaker switches must be identified as to the equipment controlled.
- ✓ Multi-plug adaptors (inclusive of extension cords, cube adaptors, and strip plugs) must meet the following requirements:
- ✓ Nationally recognized testing laboratory approval.
- ✓ Insertion into a properly grounded outlet and not used in tandem or in conjunction with other adaptors.
- ✓ Current breaker overload safety device and not exceed a maximum rating of 15 amps.
- ✓ Protection from physical damage, not affixed to structures or extended through walls, ceilings, floors, under doors or floor coverings or be subject to any damage/impact.
- ✓ No alterations in any manner.
- ✓ De-energize electrical equipment before inspecting or making repairs. Prior to inspecting or repairing equipment, turn off the current at the switch box and lockout/tagout the system. Accidental or unexpected sudden starting of electrical equipment can cause severe injury or death.
- ✓ Check the receptacle for missing or damaged parts. Do not plug equipment into defective receptacles.
- ✓ When plugging in or unplugging power equipment, the power switch must always be in the OFF position.
- ✓ Plugs must not be removed from outlets by yanking the cord.
- ✓ Care must be taken when electrical equipment is used in areas where oxygen, flammable gases, or anaesthetics are present. Sparks from electrical equipment can cause a fire or explosion.
- ✓ Insulated tools are recommended when working near energized equipment.
- ✓ When working with equipment that may pose an electrical hazard, wear the proper personal protective equipment, e.g., rubber, insulating gloves; hoods; sleeves; helmets; shoes; etc.

- ✓ Prior to beginning a task that may involve an electrical hazard, be sure you are familiar with all safety procedures.
- ✓ Supervisors are responsible for assuring that equipment such as radios, coffee pots, etc., meet the guidelines for proper grounding and other electrical safety standards.

Typical occupational categories of employees facing a higher than normal risk of electrical accident would be:

- ✓ Blue collar supervisors
- ✓ Electrical & electronic engineers
- ✓ Electrical & electronic equipment assemblers
- ✓ Electrical & electronic technicians
- ✓ Electricians
- ✓ Industrial machine operators
- ✓ Material handling equipment operators
- ✓ Mechanics and repairers (maintenance employees)
- ✓ Painters
- ✓ Riggers & roustabouts
- ✓ Stationary engineers
- ✓ Welders

Self-Check - 9	Written Test

Instruction: Follow the below selected instruction

Answer all the questions listed below. Use the Answer sheet provided in the next page:

N°	Questions and answers
1	Electrical cords must be inspected for frays, cracks, exposed wires, and to ensure that the insulating jacket is intact.
	True or false:
2	Extension cords used as a permanent source of wiring.
	True or false:
3	Insulated tools are recommended when working near energized equipment.
	True or false

Note: Satisfactory rating - 2 points **Unsatisfactory - below 2 points**

Solar PV System Installation and Maintenance

Level IV

Learning Guide -20

Unit of Competence	**Develop and Connecting Electrical Control Circuits**
Module Title	**Developing and Connecting Electrical Control Circuits**
LG Code	**EIS PIM4 M05 LO2-LG20**
TTLM Code	**EIS PIM4 TTLM 0920V1**

LO 2: Connect and test electrical control circuits

Instruction Sheet	Learning Guide:-20

This learning guide is developed to provide you the necessary information, knowledge, skills and attitude regarding the following content coverage and topics:

- Carrying out OHS risk control measures .
- Determining OHS requirements to measure in caution
- Checking Circuits/machines/plant isolating
- Connecting Control circuit components
- Testing control circuit operation
- Rectifying non-compliant control functions and comply control scenario
- Authorizing unexpected situations are safely and approval
- Connecting and testing control circuits

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:-

- Carry out OHS risk control measures .
- Determine OHS requirements to measure in caution
- Check Circuits/machines/plant isolating
- Connect Control circuit components
- Test control circuit operation
- Rectify non-compliant control functions and comply control scenario
- Authorize unexpected situations are safely and approval
- Connect and testing control circuits

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks

Information Sheet 1	Carrying out OHS risk control measures

1.1 Introduction

Solar electric (photovoltaic or PV) systems include several components that conduct electricity: the PV solar array, an inverter that converts the panel's direct current to alternating current, and other essential system parts. When any of these components are "live" with electricity generated by the sun's energy, they can cause injuries associated with electric shock and arc-flash. Even low-light conditions can create sufficient voltage to cause injury.

It's also important to recognize that with PV systems, electricity comes from two sources: the utility company and the solar array that is absorbing the sun's light. Even when a building's main breaker is shut off, the PV system will continue to produce power. This makes isolating the power source more difficult, and requires extra caution on the part of the solar worker.

1.2 Identify the hazards

Identifying hazards involves finding all of the tasks, situations and sequences of events that could potentially cause harm. Hazards arising from electrical equipment or installations may arise from:

- the design, construction, installation, maintenance and testing of electrical equipment or electrical installations
- design change or modification
- inadequate or inactive electrical protection
- Where and how electrical equipment is used. Electrical equipment may be subject to operating conditions that are likely to result in damage to the equipment or a reduction in its expected life span. For example, equipment may be at greater risk of damage if used outdoors or in a factory or workshop environment
- electrical equipment being used in an area in which the atmosphere presents a risk to health and safety from fire or explosion, for example confined spaces

- type of electrical equipment. For example, ‘plug in’ electrical equipment that may be moved around from site to site, including extension leads, are particularly liable to damage the age of electrical equipment and electrical installations
- work carried out on or near electrical equipment or electrical installations, including electric overhead lines or underground electric services, for example work carried out in a confined space connected to plant or services.
- Potential electrical hazards may be identified in a number of different ways including:
- talking to workers and observing where and how electrical equipment is used
- regularly inspecting and testing electrical equipment and electrical installations as appropriate
- reading product labels and manufacturers’ instruction manuals
- Talking to manufacturers, suppliers, industry associations, and health and safety specialist reviewing incident reports.

Self-Check – 1	Written Test

Instruction: The following are true or false statements, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	Solar electric (photovoltaic or PV) systems conduct electricity from sun light.
	True or false:
2	Reading product labels and manufacturers' instruction manuals may not reduce accidents.
	True or false:

Note: Satisfactory rating - 2 points Unsatisfactory - below 2 points

2.1 Introduction

No two worksites are the same. Before a solar installation begins, it's essential for the installer to visit the site, identify the safety risks and develop specific plans for addressing them. Plans should include:

- Equipment to be used for safe lifting and handling of solar panels
- Type and size of ladders and scaffolding if needed
- Fall protection for rooftop work
- Personal protective equipment for each installer

2.2 Assess the risks

Risk assessment involves considering what could happen if someone is exposed to a hazard (consequence) and the likelihood of it happening. For work on energized electrical equipment, the WHS Regulations require that a risk Assessment be prepared in writing by a competent person;

A risk assessment can help determine:

a) the severity of an electrical risk
b) whether existing control measures are effective
c) what action you should take to control an electrical risk
d) How urgently the action needs to be taken.

To assess the risk associated with electrical hazards consider:

- What is the potential impact of the hazard?
  - ✓ How severe could the electrical hazard be? For example, direct contact causing electrocution, fire or explosion causing serious burns or death.
  - ✓ How many people are exposed to the hazard?
- How likely is the hazard to cause harm?
  - ✓ Could it happen at any time or would it be a rare event?
  - ✓ How frequently are workers exposed to the hazard?

2.3 Control the risks

Once hazards have been identified and the risks assessed, appropriate control measures must be put in place. The ways of controlling risks are ranked from the highest level of protection and reliability to the lowest. This ranking is known as the hierarchy of risk control. You must work through this hierarchy to choose the control that most effectively eliminates or minimizes the risk in the circumstances, so far as is reasonably practicable. This may involve a single control measure or a combination of two or more different controls.

- **Elimination**

The most effective control measure is to remove the hazard or hazardous work practice. By designing-in or designing-out certain features, hazards may be eliminated.

- **Substitution**

Replacing a hazardous process or material with one that is less hazardous will reduce the hazard, and hence the risk. For example, it may be reasonably practicable to use extra low voltage electrical equipment such as a battery-operated tool rather than a tool that is plugged in to mains electricity.

- **Isolation**

Preventing workers from coming into contact with the source of an electrical hazard will reduce the relevant risks.

- **Engineering controls**

Use engineering control measures to minimize the risk, for example installing residual current devices to reduce the risk of receiving a fatal electric shock.

- **Administrative controls**

Administrative controls involve the use of safe work practices to control the risk, for example establishing exclusion zones, use of permits and warning signs.

2.4 Personal protective equipment (ppe)

PPE includes protective eyewear, insulated gloves, hard hats, aprons and breathing protection. Most forms of PPE are not relevant to minimizing electrical risks in work places, except in relation to energized electrical work.

- There are a number of things you should do to manage the risks to health and safety associated with electrical risks at the workplace including:
  - ✓ Ensure power circuits are protected by the appropriate rated fuse or circuit breaker to prevent overloading.
  - ✓ If the circuit keeps overloading, don't increase the fuse rating as this creates a fire risk
  - ✓ Due to overheating; instead ensure the circuit is not re-energized until the reason for the operation has been determined by a competent person.
  - ✓ Arrange electrical leads so they will not be damaged. So far as is reasonably practicable, avoid running leads across the floor or ground, through doorways and over sharp edges, and use lead stands or insulated cable hangers to keep leads off the ground. In many heavy industries, cable protection ramps are used to protect cables.
  - ✓ Don't use leads and tools in damp or wet conditions unless they are specially designed for those conditions.
  - ✓ Ensure circuits where portable electrical equipment can be connected are protected by appropriate RCDs (as required by the WHS Regulations) that are properly tested and maintained.
  - ✓ If RCDs, circuit breakers or other over current protective devices including fuses are triggered into operation, ensure circuits are not re-energised until the reason for the operation has been determined by a competent person.
  - ✓ Ensure RCDs are effective by regular testing.

Self-Check – 2	Written Test

Instruction: The following are true or false statements, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	To minimize an electrical risk is not needs to isolate circuit breaker.
	True or false:
2	PPE are must be relevant to minimizing electrical risks in workplaces
	True or false:
3	Controlling risks are ranked from the highest level of protection and reliability to the lowest.
	True or false:

Note: Satisfactory rating - 2 points **Unsatisfactory - below 2 points**

Information Sheet 3	Checking Circuits/machines/plant isolating

3.1 Introduction

The need to perform installation or maintenance work on electrically powered equipment necessitates that the equipment must be isolated (de-energized) so that it is safe to access. Equipment commonly used for isolating plant and machinery from electrical power includes circuit breakers, isolators, switches, links and fuses.

Simply switching off and locking an isolating switch is not sufficient. Isolations need to be proven sound. Confirming that the isolation is sound involves answering “yes” to the following two questions:

- Has the correct switch handle been turned off?
- Is the switch electrically off?

Accessing incorrectly isolated equipment could result in electric shock or injury to personnel or damage to equipment. In recent times operators, maintainers and installers of equipment have considered the risks associated with the mal-operation of isolating devices. Most manufacturers of Isolating Switches incorporate in their range a version of switches that allow an operator to view the state of the switch contacts. The aim being to enhance the confidence that when the switch is turned off – it is in fact, electrically off!

3.2 The Need to confirm isolations

The recent interest surrounding the practice of confirming isolations can be attributed to three drivers as follows:

- Worker Accidents
- Industry Regulations and Codes of Practice
- Isolation Switch Failures

3.3 Electrical work on electrical installations—safety measures

- An employer must ensure that any electrical work on an electrical installation at a place of work is carried out using a safe system of work.

- An employer must ensure that such work is not carried out while the installation's circuits and apparatus are energized.
- The safe system of work must include checks to ensure the installation's circuits and apparatus are not energized before work commences and remain that way until the work is completed. **"**Machine isolation shall be designed so that verifying and, if necessary, testing of the effectiveness of the isolation ... can be performed easily and reliably**"**

3.4 Switch Failures

Whilst most accidents occur when workers do not isolate properly, even after following the correct procedures accidents still happen. Switch failure mechanisms that have been reported include:

- Welded switch contacts
- Worn handles that fail to rotate the switch mechanism when the handle is rotated
- Misaligned handles that fail to engage with the "handle to switch" connecting shaft
- Switch bypass faults – cable-to-cable faults

3.4.1. Current Practice

Three methods are commonly used by Industry to address the requirement for confirming isolations. They are:

- "Test Dead at Load"
- "Attempt Start" & "Test Dead at Load"
- Isolation Switch – line & load side pilot lamps

"Test Dead at Load" Isolation Procedure

A single line diagram and simple control circuit for a typical, remotely controlled motor is depicted below as Figure

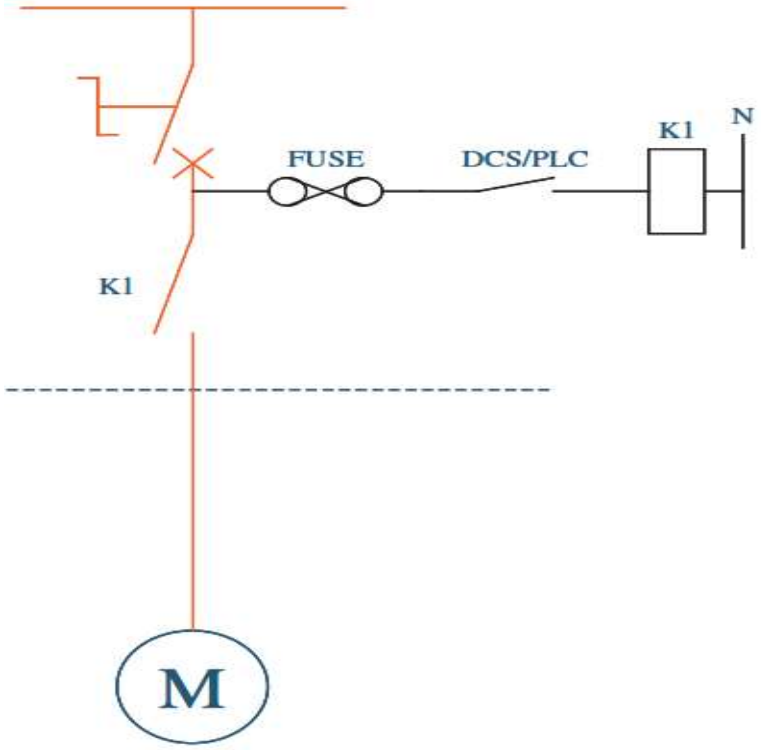


Figure 18: remote control motor

The “Testing Dead” Isolation Procedure simply involves turning the Isolating Switch off and locking the switch, followed by testing all active conductors for the absence of power. In step form the procedure is as follows:

- ✓ Isolate the switch (in the substation)
- ✓ Lockout the switch (in the substation)
- ✓ Test each line
- ✓ side phase of the isolating switch for system voltage (in the substation)
- ✓ Test each load side phase of the isolating switch for the absence of system voltage (in the substation)
- ✓ Test each phase of the motor supply for the absence of system voltage (at the motor)
- ✓ Test the voltmeter for operation on a known voltage source

To illustrate the situation, Figure below depicts a simple pumping system where the supply tank delivers to the delivery tank under the automatic control of a level switch and

actuated pump. In the circumstance when the pump has failed and requires replacement consider the application of the“ Testing Dead” Isolation Procedure.

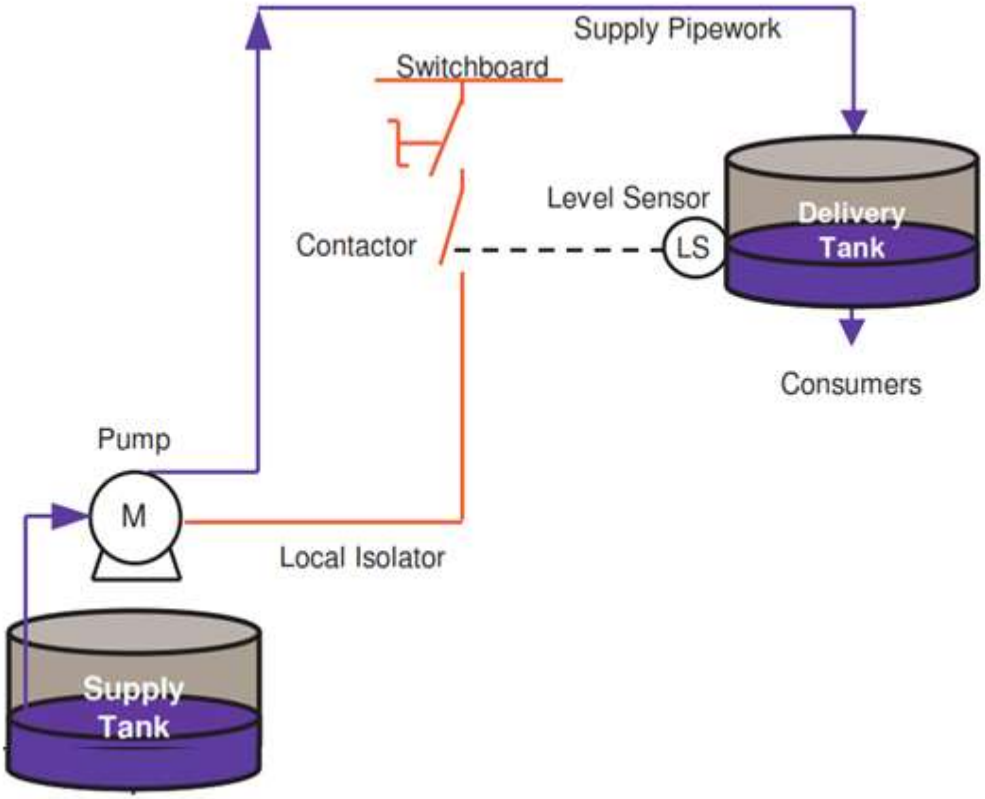


Figure 19: simple pumping system

Self-Check – 3	Written Test

Instruction: choose the best answers

N°	Questions and answers	
1	Equipment commonly used for isolating plant and machinery from electrical power except, , , links and	
	A. circuit breakers	B. isolators
	C. switches	D. Lamp
2	One of the following is not components of control pumping system.	
	Level sensor	pump
	Tanker	none
3	An electrical protective devices automatically turn off in fault condition and after maintain the fault to return to normal operation is	
	circuit Breaker	Fuse
	Relays	Contactor
4	Electrical protective devices automatically melt in fault condition.	
	circuit Breaker	Fuse
	Relays	Contactor

Note: Satisfactory rating -3 points Unsatisfactory - below 2 points

Information Sheet 4	Connecting Control circuit components

4.1 Introduction

In the industry we use three methods for transmitting power from one point to another. Mechanical transmission is through shafts, gears, chains, belts, etc. Electrical transmission is through wires, transformers, etc. Fluid power is through liquids or gas in a confined space. In this chapter, we shall discuss a structure of hydraulic systems and pneumatic systems. We will also discuss the advantages and disadvantages and compare hydraulic, pneumatic, electrical and mechanical systems.

4.2 Basic Components of a Hydraulic System

Hydraulic systems are power-transmitting assemblies employing pressurized liquid as a fluid for transmitting energy from an energy-generating source to an energy-using point to accomplish useful work. Figure below shows a simple circuit of a hydraulic system with basic components.

- **The major Components of Hydraulic System**
  - ✓ Prime mover
  - ✓ Pump
  - ✓ Control valves
  - ✓ Actuator
  - ✓ Piping system
  - ✓ Fluid
  - ✓ motor

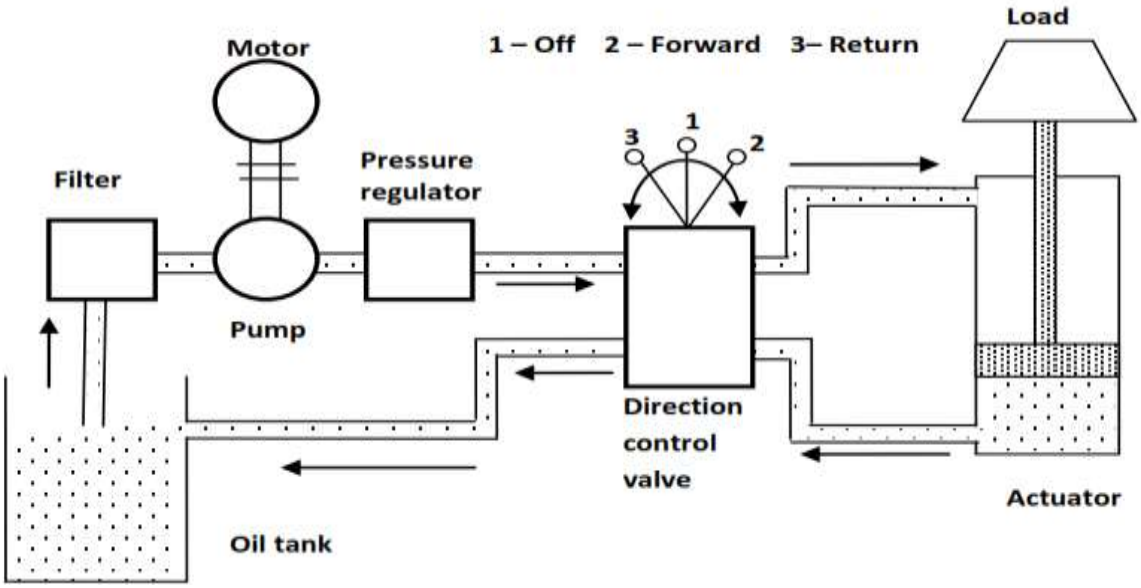


Figure 20: Components of a hydraulic system

- **Functions of the components**
  - ✓ The hydraulic actuator is a device used to convert the fluid power into mechanical power to do useful work. The actuator may be of the linear type (e.g., hydraulic cylinder) or rotary type(e.g., hydraulic motor) to provide linear or rotary motion, respectively.
  - ✓ The hydraulic pump is used to force the fluid from the reservoir to rest of the hydraulic circuit by converting mechanical energy into hydraulic energy.
  - ✓ Valves are used to control the direction, pressure and flow rate of a fluid flowing through the circuit.
  - ✓ External power supply (motor) is required to drive the pump.
  - ✓ Reservoir is used to hold the hydraulic liquid, usually hydraulic oil.
  - ✓ Piping system carries the hydraulic oil from one place to another.
  - ✓ Filters are used to remove any foreign particles so as keep the fluid system clean and efficient, as well as avoid damage to the actuator and valves.
  - ✓ Pressure regulator regulates (i.e., maintains) the required level of pressure in the hydraulic fluid.

- **Cylinder movement is controlled by a three-position change over a control valve.**
  - ✓ When the piston of the valve is changed to upper position, the pipe pressure line is connected to port A and thus the load is raised.
  - ✓ When the position of the valve is changed to lower position, the pipe pressure line is connected to port B and thus the load is lowered.
  - ✓ When the valve is at center position, it locks the fluid into the cylinder(thereby holding it in position) and dead-ends the fluid line (causing all the pump output fluid to return to tank via the pressure relief).

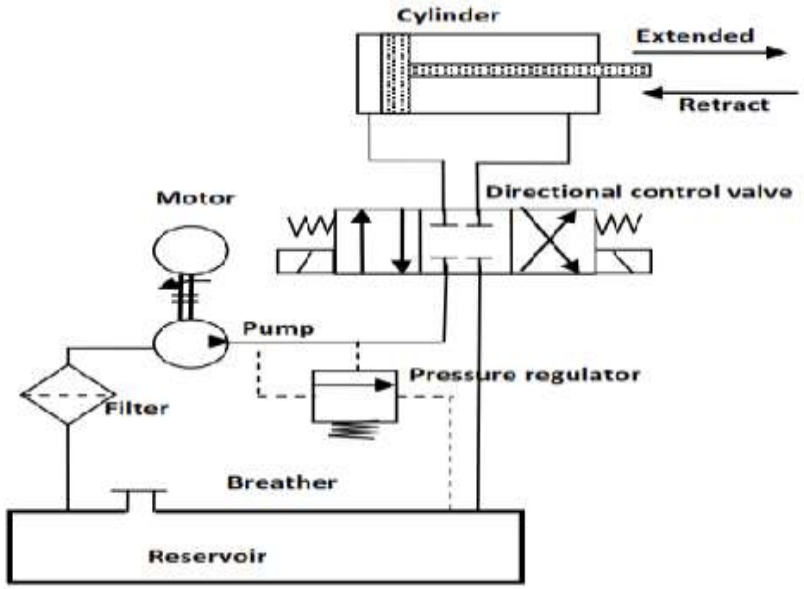


Figure 21: Components of a hydraulic system (shown using symbols).

4.3 Basic Components of a Pneumatic System

A pneumatic system carries power by employing compressed gas, generally air, as a fluid for transmitting energy from an energy-generating source to an energy-using point to accomplish useful work. Figure below shows a simple circuit of a pneumatic system with basic components.

- **Components of a Pneumatic System**
  - ✓ Compressor
  - ✓ Receiver

- ✓ Air distribution lines
- ✓ FLR unit
- ✓ Pneumatic actuators
- ✓ Pneumatic control valves
- ✓ Air driers
- ✓ Motor

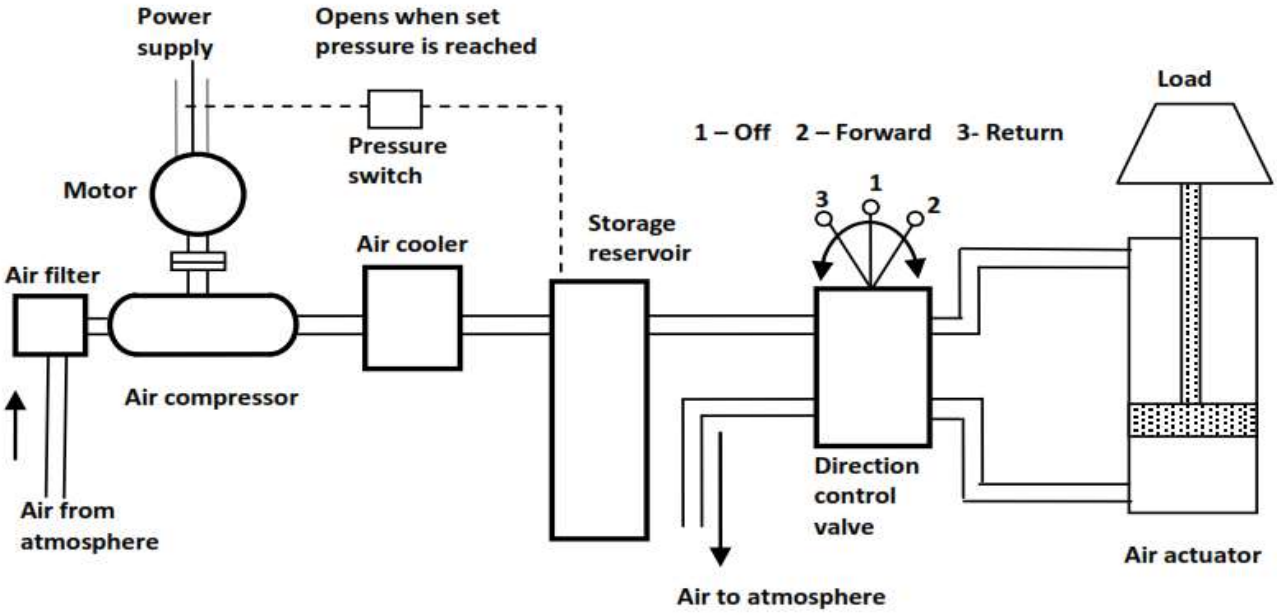


Figure 22: Components of a pneumatic system.

The functions of various components shown in Fig. above are as follows:

- ✓ The pneumatic actuator converts the fluid power into mechanical power to perform useful work.
- ✓ The compressor is used to compress the fresh air drawn from the atmosphere.
- ✓ The storage reservoir is used to store a given volume of compressed air.
- ✓ The valves are used to control the direction, flow rate and pressure of compressed air.
- ✓ External power supply (motor) is used to drive the compressor.
- ✓ The piping system carries the pressurized air from one location to another.

The three-position change over the valve delivering air to the cylinder operates in a way similar to its hydraulic circuit.

Table 2: Comparison between a hydraulic and a pneumatic system</table>

S. No.	Hydraulic System	Pneumatic System
1	It employs a pressurized liquid as a fluid	It employs a compressed gas, usually air, as a fluid
2	An oil hydraulic system operates at pressures up to 700 bar	A pneumatic system usually operates at 5–10 bar
3	Generally designed as closed system	Usually designed as open system
4	The system slows down when leakage occurs	Leakage does not affect the system much
5	Valve operations are difficult	Valve operations are easy
6	Heavier in weight	Lighter in weight
7	Pumps are used to provide pressurized liquids	Compressors are used to provide compressed gases
8	The system is unsafe to fire hazards	The system is free from fire hazards
9	Automatic lubrication is provided	Special arrangements for lubrication are needed

4.4 Electrical Control devices

Every control circuit is composed of a number of basic components connected together to achieve the desired performance. The size of the components varies with the power of the motor, but the principle of operation remains the same.

- **The basic components are the following:**
  - ✓ Disconnecting switches
  - ✓ Manual circuit breakers
  - ✓ Pushbuttons
  - ✓ Relays
  - ✓ Magnetic contactors
  - ✓ Thermal relays and fuses

- ✓ Pilot lights
- ✓ Limit switches and other special switches

- **Line Diagrams**
  - ✓ A line (ladder) diagram is a diagram that shows the logic of an electrical circuit or system using standard symbols. „
  - ✓ A line diagram is used to show the relationship between circuits and their components but not the actual location of the components. „
  - ✓ Line diagrams provide a fast, easy understanding of the connections and use of components.

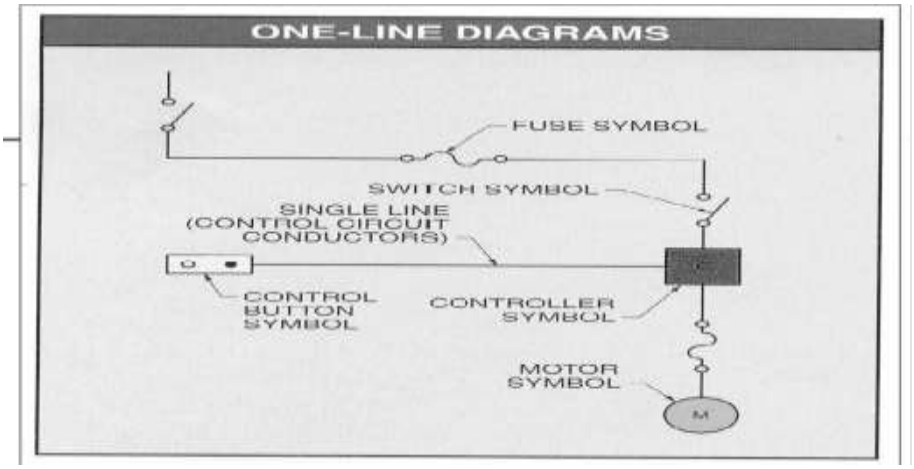


Figure 23: line diagram

- **Wiring Diagrams**
  - ✓ Wiring (connection) diagram – a diagram that shows the connection of an installation or its component devices or parts.
  - ✓ Wiring diagrams show, as closely as possible, the actual location of each component in a circuit, including the control circuit and the power circuit.

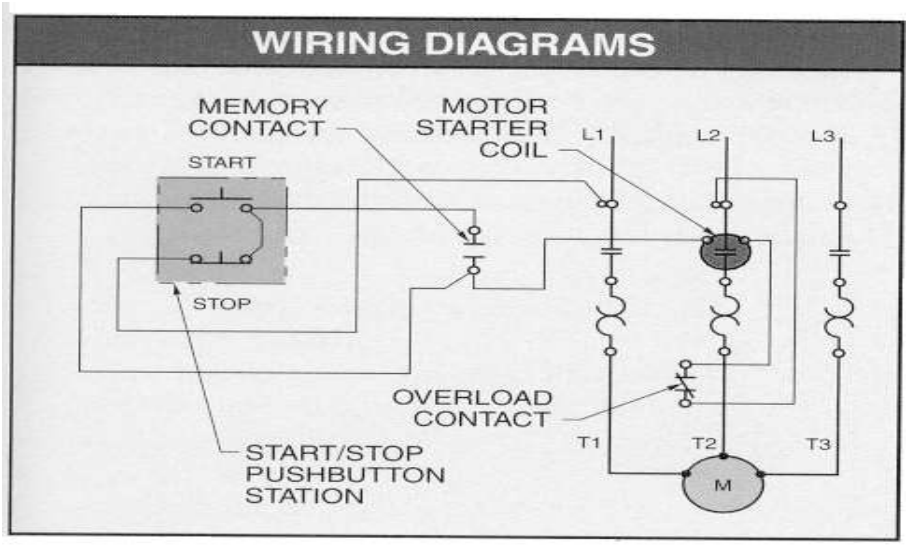


Figure 24: Wiring diagram

Self-Check – 4	Written Test

Instruction: choose the best answers

N°	Questions and answers	
1	One of the following is not basic components of a hydraulic system.	
	A. Prime mover	B. Pump
	C. Air distribution lines	D. Control valves
2	One of the following is not Components of a Pneumatic System.	
	A. Compressor	B. Receiver
	C. Air distribution lines	D. Fluid
3	Every control circuit is composed of a number of basic components connected together to achieve the desired performance except.	
	A. Compressor	B. Fuse
	C. Relays	D. Contactor
4	hydraulic system operated by the power of	
	A. fluid	B. air
	C. current	D. all
5	Pneumatic system operated by the power of	
	A. fluid	B. air
	C. current	D. all

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Information Sheet 5	Testing control circuit operation

5.1 Introduction

A wiring diagram shows, as closely as possible, the actual location of all component parts of the device. The open terminals (marked by an open circle) and arrows represent connections made by the user.

Power circuits are used to supply AC current to those devices. Often the phrases “line voltage” or “mains” are used to describe the supply of 120V/380v

5.2 Control and power circuit

- **Manual Control Circuits**
  - ✓ Manual control circuit – any circuit that requires a person to initiate an action for the circuit to operate.
  - ✓ A line diagram may be used to illustrate a manual control circuit of a push button controlling a pilot light.
  - ✓ A line diagram may be used to illustrate the control and protection of a 1ϕ motor using a manual starter with overload protection.

- **Automatic Control Circuits**
  - ✓ Automatically-controlled devices have replaced many jobs that were once performed manually.
  - ✓ As a part of automation, control circuits are designed to replace manual devices.

- **Magnetic Control Circuits**
  - ✓ Although manual controls are compact and sometimes less expensive than magnetic controls, industrial and commercial installations often require that electrical control equipment be located in one area while the load device is located in another.
  - ✓ Solenoids, contactors, and magnetic motor starters are used for remote control of devices.

- ✓ A solenoid is an electrical device that converts electrical energy in to a linear mechanical force.

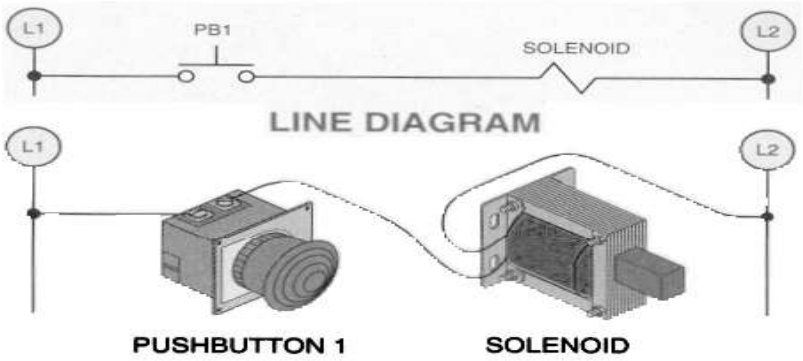


Figure 25: solenoid device connect

- **Contactors**
  - ✓ Contactor – a control device that uses a small control current to energize or de-energize the load connected to it.
  - ✓ A contactor does not include overload protection.
  - ✓ A contactor has a frame, plunger, and coil like a solenoid.
  - ✓ The action of the plunger, however, is directed to close (or open) sets of contacts.
  - ✓ The closing of the contacts allows electrical devices to be controlled from remote locations.

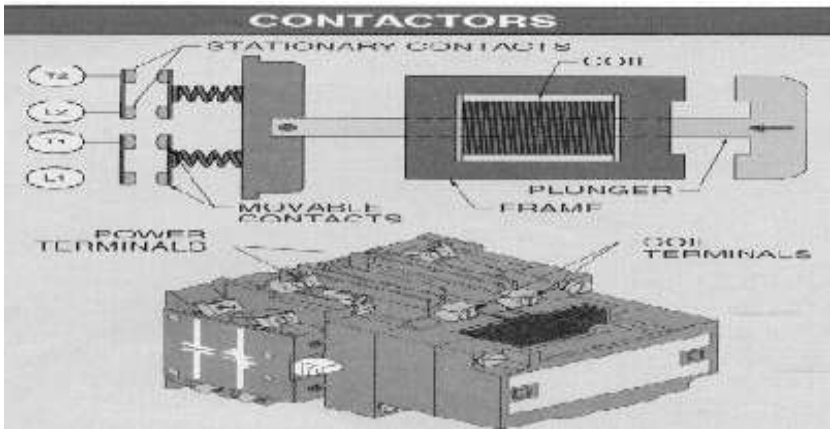


Figure 26: magnetic contactor

- Magnetic Motor Starters
- A magnetic motor starter is an electrically-operated switch (contactor) that includes motor overload protection.
- Magnetic motor starters are identical to contactors except that they have overloads attached to them.
- The overloads have heaters or electronic overloads (located in the power circuit) which sense excessive current flow to the motor.
- The heaters open the NC overload contacts (located in the control circuit) when the overload becomes dangerous to the motor.

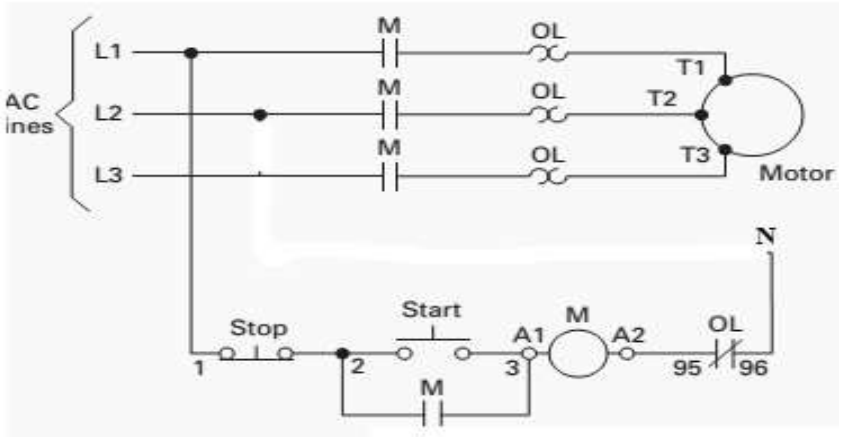


Figure 27: On line diagram motor control

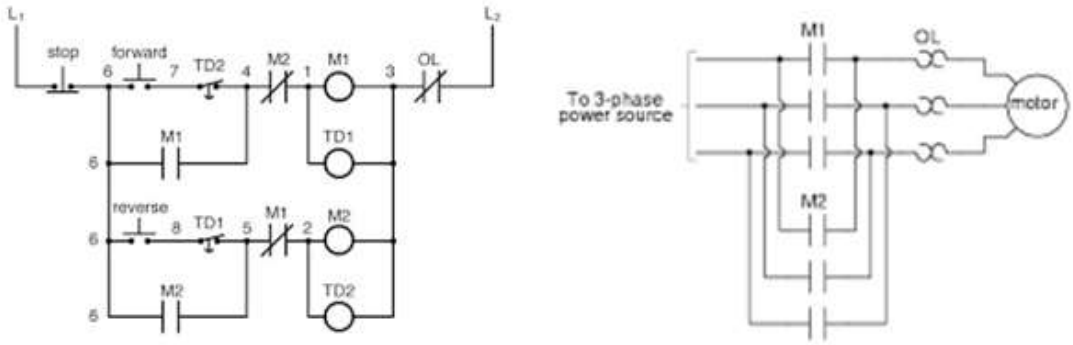


Figure 28: control and power circuit motor control

5.3 Logic Applied to Line Diagrams

- The electrical industry has established a universal set of symbols and rules on how line diagrams (circuits) are laid out.
- No more than one load should be placed in any one circuit line between L1 and L2.
- A pilot light can be connected into a circuit with single-pole switch.

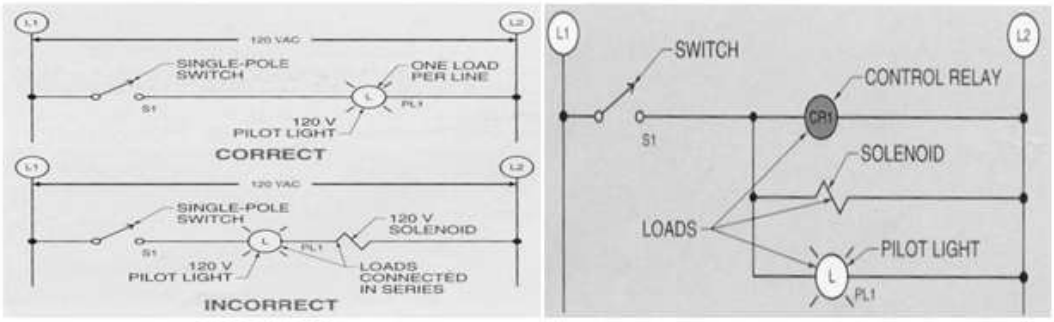


Figure 29: control relays solenoids and pilot light

- ✓ Control devices are connected betweenL1 and the operating coil (or load).
- ✓ Operating coils of contactors and starters are activated by control devices such as pushbuttons, limit switches, and pressure switches.

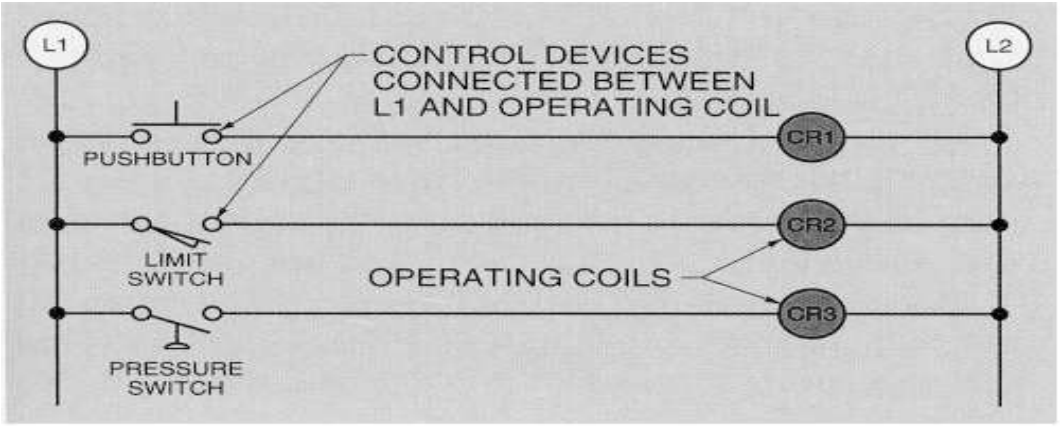


Figure 30: Control devices

5.4 programmable logic controller(PLC),

A programmable logic controller (PLC), also referred to as a programmable controller, is the name given to a type of computer commonly used in commercial and Industrial control applications. The basic elements of a PLC include input modules or points, a central processing unit (CPU), output module .or points and a programming device.

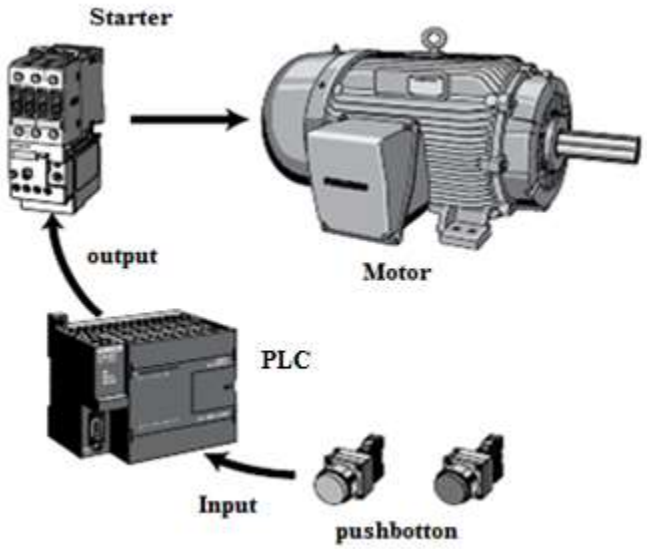


Figure 31: Basic PLC

- **Ladder Logic Programming**

A program consists of instructions that accomplish specific tasks. The degree of complexity of a PLC program depends upon the complexity of the application the number and type of Input and output devices and the types of instructions used.

Ladder logic (LAD) is one programming language used with PLCs Ladder logic incorporates programming functions that are graphically displayed to resemble symbols used in hard-wired

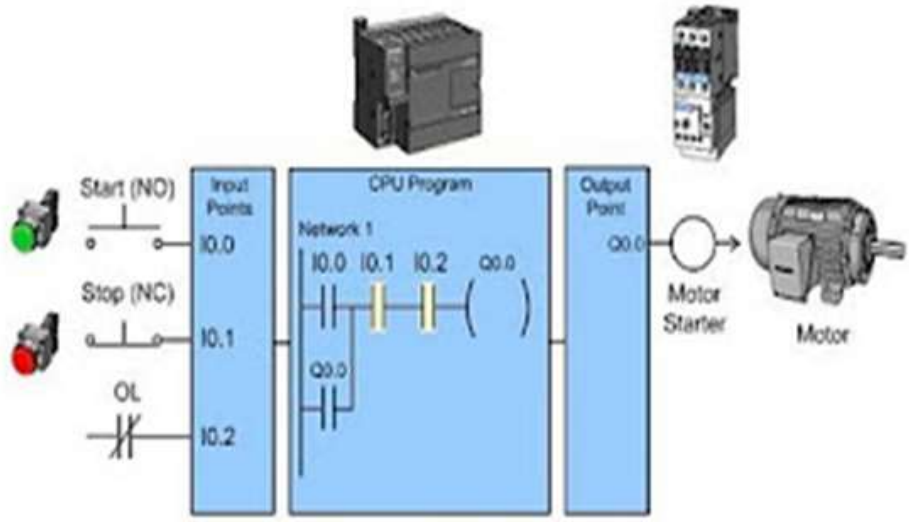


Figure 32: Ladder Logic Programming

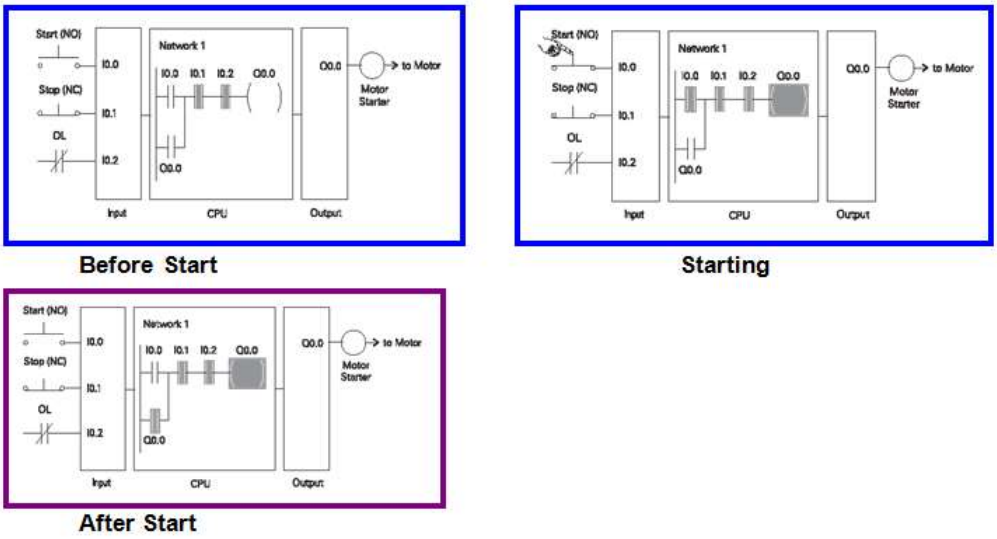


Figure 33: logic programming

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Self-Check – 5	Written Test

Instruction: choose the best answers

N°	Questions and answers	
1	One of the following is not components of power circuit.	
	A. push button	B. motor
	C. contactors	D. power line
2	One of the following is not Components of PLC System.	
	motor	pushbutton
	PLC	Fluid
3	One of the following is not electrical protective device	
	Fuse	Ground
	contactor	relay
4	The basic elements of a PLC include or points, a central .or points and a programming device.	
	input modules	processing unit (CPU),
	output module	All

Note: Satisfactory rating - 3 points **Unsatisfactory - below 3 points**

Information Sheet 6	Rectifying non-compliant control functions and comply control scenario

6.1 Introduction

Here are some key verbal intervention tips when dealing with noncompliant behaviour:

- Maintain your rationality
- Place responsibility where it belongs
- Explain the directive
- Set reasonable limits
- Be prepared to enforce your limits
- Don't stress the negative

Non-compliance may result in fines, litigation, or other consequences for the employing organisation that may have a material effect on its financial statement and may also affect negatively investors, creditors, employees or general public. Measure the current by connecting the positive test lead from the multi meter to the positive cable from the controller and the negative test lead from the multi meter to the positive battery terminal. This measures the current that the panel and charge controller are passing to the battery.

Performance criteria describe the required performance needed to demonstrate achievement of the Element. Assessment of performance is to be consistent with the evidence guide.

- Established OHS risk control measures and procedures in preparation for the work are followed.
- Safety hazards, which have not previously been identified, are noted and established risk control measures are implemented.
- Control scenarios are determined from discussions with appropriate person(s) and documented in accordance with established procedures.
- Schematic arrangement of control circuits that complies with agreed scenarios is documented in accordance with established procedures.

- Tools, equipment and testing devices needed to connect control circuits are obtained in accordance with established procedures and checked for correct operation and safety.
- Circuits/machines/plant are checked as being isolated where necessary in strict accordance OHS requirements and procedures.
- Control circuit components are connected to comply with the agreed control scenario.
- Control circuit operation is tested for agreed functionality and in strict accordance with OHS requirements and established safety procedures.
- Non-compliant control functions are rectified to comply with the agreed control scenario.
- Unexpected situations are dealt with safely and with the approval of an authorized person.
- Control circuits are connected and tested efficiently without unnecessary waste of materials or damage to apparatus, circuits, the surrounding environment or services and using sustainable energy practice.

6.2 Required Skills and Knowledge

Evidence shall show that knowledge has been acquired of safe working practices and developing and connecting control circuits. All knowledge and skills detailed in this unit should be contextualized to current industry practices and technologies.

- **Basic control circuits encompassing**
  - ✓ Identification of given circuit diagrams (schematic) symbols and explain the operation of the components represented labeling wires and terminal (numbering systems)
  - ✓ control relay - operating principles, basic contact configurations and identification and common applications
  - ✓ push button - switching configurations and common applications
  - ✓ selecting pushbuttons/pilot lamps from manufacturer's catalogues for specific applications

- ✓ Developments of simple stop-start relay circuit that incorporates pilot lights and latching circuit.
- ✓ connection and testing of control circuits

- **Control devices encompassing**
  - ✓ common control devices used in automatic control circuits: limit switches, proximity switches, photoelectric cells, pressure switches, float switches, light sensors and temperature sensors
  - ✓ basic operating principles of common control devices
  - ✓ advantages and disadvantages of common control devices
  - ✓ applications for common control devices
  - ✓ selecting control devices using manufacturers' catalogues for specified applications
  - ✓ connection of control devices into control circuits
  - ✓ programmable relays - advantages over electromagnetic relay circuit control
  - ✓ star-delta starter operating principles and circuits
  - ✓ comparison of motor starters basic characteristics

Self-Check – 6	Written Test

Instruction: The following are true or false statements, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	Control scenarios are determined from discussions with appropriate person(s) and documented in accordance with established procedures
	True or false:
2	Non-compliant control functions are rectified to comply with the agreed control scenario.
	True or false
3	Control circuits are connected and tested efficiently without unnecessary waste of materials or damage to apparatus,
	True or false
4	To test control circuit is not consider selecting of electrical testing materials.
	True or false

Note: Satisfactory rating - 3 points Unsatisfactory - below 3 points

Information sheet-7	Authorizing unexpected situations are safely and approval

7.1 Introduction

Use the adjective unexpected to describe something that takes you by surprise. A successful surprise party is always unexpected, and an unexpected visitor can be exciting or inconvenient, depending on whom it is. If you expect an event, you know it's going to occur, but if it's unexpected, it seems to come from nowhere. To give authority or official power to; empower: to authorize an employee to sign purchase orders. To give authority for; formally sanction (an act or proceeding): Congress authorized the new tax on tobacco.

7.2 Safety approval

A safety approval is an determination that one or more safety elements, when used or employed within a defined envelope, parameter, or situation, will not jeopardize public health and safety, or safety of property and is capable of providing the documented capability within the specified operating envelope. A safety approval may be issued independent of a license or permit and it does not confer any authority to conduct activities for which a license or permit is required.

Safety element - A safety element is a launch or re-entry vehicle, safety system, process, service, or any identified component thereof; or qualified and trained personnel used in conducting or supporting a licensed or permitted launch or re-entry. Use of a safety-approved safety element, will facilitate launch and re-entry licensing.

7.3 Hat a safety approval is not

- **A safety approval is not:**
  - ✓ a finding, guarantee, or warranty that an approved safety element will reliably or consistently function in accordance with manufacturer specifications,
  - ✓ a relief to its holder of the duty to comply with all applicable requirements of law or regulation,

- ✓ an FAA certification of a vehicle or component design, or of services involved in a licensed or permitted launch or re-entry,
- ✓ an indication of mission success or failure,
- ✓ a finding of suitability for purposes outside the stated limitations of the safety approval,

- **Safety approval eligibility**

WHO IS ELIGIBLE FOR A SAFETY APPROVAL?

There is no citizenship requirement to obtain a safety approval. You may be eligible for a safety approval if you are:

- ✓ a manufacturer or designer of a launch or re-entry vehicle or component,
- ✓ a designer or developer of a safety system or process,
- ✓ a person who performs safety critical functions to be used in conducting a licensed or permitted launch or re-entry, or
- ✓ a company providing a service in support of a launch operation. The applicant must have sufficient knowledge and expertise with the safety element for which it seeks a safety approval in order to demonstrate that its design and operation qualifies for a safety approval.

- **A safety approval may be appropriate for:**
  - ✓ Launch or re-entry vehicles
  - ✓ Safety systems, e.g., flight safety systems, on-board and ground tracking systems, and vehicle health monitoring systems, including individual elements thereof
  - ✓ Safety-related processes and services, such as training
  - ✓ System testing procedures
  - ✓ Manufacturing procedures
  - ✓ Flight testing processes or procedures
  - ✓ Flight safety analysis services, such as wind weighting and risk assessment
  - ✓ Flight safety monitoring systems, such as a sky-screen
  - ✓ Safety officials (flight and range)
  - ✓ Radar operators

- **Safety approval maintenance**
  - ✓ The safety approval holder is responsible for maintaining a valid safety approval. The approval holder must ensure the continued accuracy and completeness of representations contained in the safety approval application.
  - ✓ If at any time information provided by an applicant as part of a safety approval application is no longer accurate and complete, the holder must submit to AST a statement furnishing the new or corrected information.
  - ✓ An approval holder's failure to do so is a sufficient basis for suspension or revocation of a safety approval any time during the five year period.

- **Application Authorizations**

An application must be legibly signed, dated, and certified as true, complete, and accurate by one of the following:

- ✓ An officer authorized to act for the corporation,
- ✓ A general partner or proprietor, respectively, or
- ✓ An officer or other individual duly authorized to act for a joint venture, association, or other entity.

- **Safety approval usage**

A safety approval allows a license or permit applicant to use an approved safety element in its proposed launch or re-entry without requiring re-examination of the safety element's performance characteristics. The performance characteristics of the safety element were already provided as part of the safety approval. However, the license or permit applicant will need to show evidence that the safety element is suitable for the particular launch or re-entry being proposed.

Self-Check – 7	Written Test

Instruction: Follow the below selected instruction

The following are true or false statements, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	**The safety approval holder is responsible for maintaining a valid safety approval**
	True or false:
2	A safety approval allows a license or permit applicant to use an approved safety element in its proposed launch or re-entry without requiring re-examination of the safety element's performance characteristics.
	True or false:
3	A safety approval may be appropriate for system operators
	True or false:

Note: Satisfactory rating - 2 points **Unsatisfactory - below 2 points**

Information sheet-8	Connecting and testing control circuits

8.1 Introduction

In electronics, a circuit is a path between two or more points along which an electrical current can be carried. (A circuit breaker is a device that interrupts the path when necessary to protect other devices attached to the circuit - for example, in case of a power surge.

In telecommunications, a circuit is a discrete (specific) path between two or more points along which signals can be carried. Unless otherwise qualified, a circuit is a physical path, consisting of one or more wires (or wireless paths) and possibly intermediate switching points. A network is an arrangement of circuits. In a dial-up (switched) connection, a circuit is reserved for use by one user for the duration of the calling session. In a dedicated or leased line arrangement, a circuit is reserved in advance and can only be used by the owner or renter of the circuit.

A virtual circuit, sometimes called a logical circuit, is a path between two or more points that seems like a fixed physical path, but actually is one path out of many possible physical paths that can be arranged. A permanent virtual circuit(PVC) is a virtual circuit that provides a guaranteed connection between two or more points when needed without having to reserve or commit to a specific physical path in advance. This allows many companies to share a common pool of circuits. This approach is used in a frame relay network and offers a committed set of resources to a telephone company customer at a lower price than if the customer leases their own circuits. A switched virtual circuit (SVC) is similar to a permanent virtual circuit, but allows users to dial in to the network of virtual circuits.

- **What is a circuit?**

All electrical supplies are formed into circuits, some of which are simple paths along which current - ows from positive to negative; others are more complex, made up of multiple routes and switching systems.

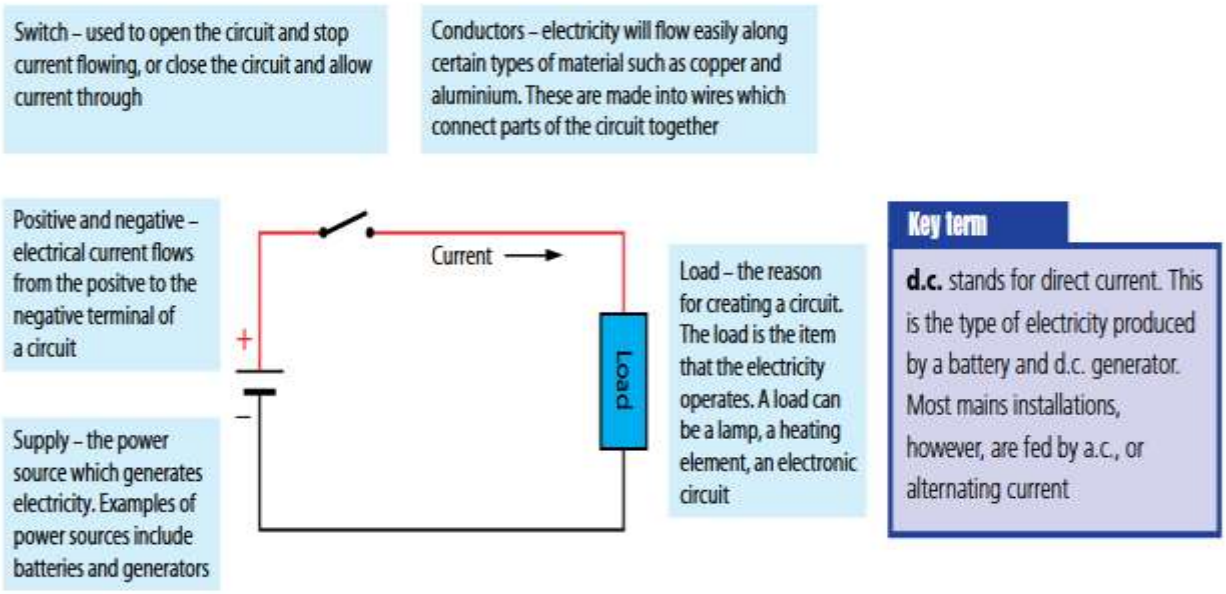

Figure 34: electrical circuit

- **Electrical Testing**

It is the job of a test technician to know which piece of test equipment to use for the task at hand and also understand the limitations of the test equipment they are using. Electrical testing in its most basic form is the act of applying a voltage or current to a circuit and comparing the measured value to an expected result. Electrical test equipment verifies the math behind a circuit and each piece of test equipment is designed for a specific application.

It is the job of a test technician to know which piece of test equipment to use for the task at hand and also understand the limitations of the test equipment they are using. In this article, we take a look at the most common piece of test equipment used in the field.

Electrical test equipment should be considered a source of lethal electrical energy. Technicians must observe all safety warnings and follow all practical safety precautions to prevent contact with energized parts of the equipment and related circuits, including the use of appropriate Personal Protective Equipment.

Figure 35: Multi meter

Also known as a VOM (Volt-Ohm meter), a multi-meter is a handheld device that combines several measurement functions (such as voltage, current, resistance and frequency) into a single unit. Multi-meters are mainly used to troubleshoot electrical problems in a wide array of industrial and household devices such as electronic equipment, motor controls, domestic appliances, power supplies, and wiring systems. Digital multi-meters are the most common form of meter used today; however analog multi-meters are still preferable in some cases, like when monitoring a rapidly changing value or sensitive measurements, like testing for CT polarity.

Megohmmeter

Figure 36: Megohmmeter

Megohmmeter are one of the most frequently used pieces of test equipment. most commonly referred to as simply a “megger”, a Megohmmeter is a special type of ohmmeter used to measure the electrical resistance of insulators. Resistances values by Megohmmeter may range from several megohms to several million megohms (teraohms). Megohmmeter produce high voltages via battery powered internal circuitry or a manually operated generator with outputs ranging from 250 to 15,000 volts. Megohmmeter are one of the most frequently used pieces of test equipment and can be used to measure the insulation of various types of apparatus such as circuit breakers, transformers, switchgear and cables.

Figure 37: low resistance ohmmeter

Often called a DLRO in the field, the low-resistance ohmmeter is used for making high-precision resistance measurements below 1 ohm. Low-Resistance ohmmeters produce low voltage DC currents via battery power with outputs of up to 100A. Resistance measurements are achieved with four terminals, called Kelvin contacts. Two terminals carry the current from the meter (C1, C2), while the other two allow the meter to measure the voltage across the resistor (P1, P2). With this type of meter, any voltage drop due to the resistance of the first pair of leads and their contact resistances is ignored by the meter. Low-Resistance ohmmeters are one of the most frequently used pieces of test equipment and can be used to measure the resistance of various types of apparatus such as circuit breaker and switch contacts, cable and path way, transformers and generators, motor windings, and fuses.

Figure 38: High current test set

A high current test set may consist of two pieces known as a “control unit” and an “output unit”, or these functions may be combined in a single package. Low voltage, high current outputs are used for primary-injection testing of low voltage circuit breakers. The high current or “primary-injection” test set consists of large transformers that step down line voltage (ex. 480V) to a very low level, such as 2-15V. The large reduction in voltage allows for a large increase in available current output (15kA+), especially for a short duration. Current output is controlled by a tap changer and variable resistor.

Integrated timers display the period between current on and current off to indicate how long it takes for a circuit breaker to trip. Circuit breakers may be connected directly to the high current test set via bus or cable. Depending on the size, this type of test equipment can also use to test ground fault and other current relays by connecting directly to switchgear bus.

Figure 39: Power Factor Test Sets

Power Factor Test Sets provide a comprehensive AC insulation diagnostic test for high voltage apparatus, such as transformers, bushings, circuit breakers, cables, lightning arrestors, and rotating machinery. Test voltages are generally 12kV and below, the power factor test set measures voltage and current of the device under test using reference impedance. All reported results – including power loss, power factor, and capacitance – are derived from the vector voltage and current. Tests are made by measuring the capacitance and dissipation factor (power factor) of a specimen. The values measured will change when undesirable conditions exist, such as moisture on or in the insulation; presence of conductive contaminants in insulating oil, gas or solids; presence of internal partial discharges etc.

Test connections include a single high voltage lead, (2) low voltage leads and a ground. Safety switches and a strobe light are included for operator protection and a temperature sensor is used to correct test values. Power factor test sets are usually operated with a laptop computer connected via USB or Ethernet.

Figure 40: ground resistance test set

The ground resistance test set works by injecting a current into the earth between a test electrode and a remote probe, measures the voltage drop caused by the soil to a designated point, and then use Ohm's Law to calculate the resistance. Ground resistance test sets come in a variety of styles with the most common being the 4-terminal unit for soil resistivity testing and the 3-terminal unit for fall-of-potential testing. Copper rods or similar stakes are used to make contact with the earth along with spools of small stranded wire to cover long distance measurements. Clamp-On Ground Resistance Testers measure ground rod and grid resistance without the use of auxiliary ground rods. They offer accurate readings without disconnecting the ground system under test but come with limitations.

Figure 41: infrared camera

Thermal imagers are camera that detect invisible infrared radiation and convert that data into a colored image on a screen. Infrared cameras are most commonly used for inspecting the integrity of electrical systems because test procedures are non-contact and can be performed quickly with equipment in service. Comparing the thermal signature of a normally operating piece of equipment to the one being evaluated for abnormal conditions offers an excellent means of troubleshooting. Even if an abnormal thermal image is not fully understood, it can be used to determine if further testing may be required. Thermal imagers are classified based on their accuracy and detector resolution. High end infrared cameras feature high resolution image capture and temperature accuracy down to a tenth of a degree or less.

Self-Check – 8	Written Test

Instruction: Follow the below selected instruction

The following are true or false statements, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	Thermal imagers are classified based on their accuracy and detector resolution
	True or false:
2	Thermal imagers are camera that detect invisible infrared radiation and convert that data into a colored image on a screen.
	True or false:
3	Clamp-On Ground Resistance Testers measure ground rod and grid resistance with the use of auxiliary ground rods
	True or false:
4	Current measurements are achieved with four terminals, called Kelvin contacts.
	True or false:

Note: Satisfactory rating - 3 points Unsatisfactory - below 2 points

Solar PV System Installation and Maintenance

Level IV

Learning Guide -21

Unit of Competence	**Develop and Connect Electrical Control Circuit**
Module Title	**Developing and Connecting Electrical Control Circuit**
LG Code	**EIS PIM4 M05 LO3-LG-21**
TTLM Code	**EIS PIM4 TTLM 0920v1**

LO3: Completion and document circuit development activities

Instruction Sheet	Learning Guide:-21

This learning guide is developed to provide you with the necessary information, knowledge, skills and attitude regarding the following content coverage and topics:

- Completion risk control measures and procedures are followed strictly.
- Work site is cleaned and made safe in accordance with established procedures
- 'As-connected' control circuits are documented using standard drawing conventions and an appropriate person or persons notified in accordance with established procedures.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:-

- Follow strictly OHS risk control measures
- Clean and making Work site
- Connect control circuits using standard drawing procedures

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks

1.1. Introduction

Risk management is the process of formulating and implementing a course of action to mitigate the hazards determined in the risk-assessment process to be important. A risk assessment is a process of evaluating what can affect the health and safety of employees at work. In broad terms, a risk assessment looks at what could go wrong and what is needed to stop it from going wrong and assesses the effectiveness of any control measures in place. Recommendations for extra control measures can then be made on the basis that they are “reasonably practicable”. This topic helps you understand your legal obligations towards risk assessment and how the process can minimize health and safety risks in an organization.

Recognized hazards can be managed with a variety of adjustments in work practices, equipment, and facilities. In some cases, key modifications focus on engineering controls (facilities and equipment), in others on administrative changes (such as delegation of decision-making authority to the right level or revision of established safety procedures), and in still others on adoption of new safety-related devices, protective equipment, or research methods.

Figure 42: The risk management process

1.2. General principles

- The competent authority should ensure that criteria are established for safety in the use of hazardous chemicals including criteria for the measures outlined in (Elimination) to (measures for disposal and treatment).

- After reviewing the chemicals being used at work, obtaining information about their hazards and making an assessment of the potential risks involved, employers should take steps to limit exposure of workers to hazardous chemicals, on the basis of the measures outlined in order to protect workers against hazards from the use of chemicals at work.

- For new work activities involving the use of chemicals, the hazards should be identified and the risks assessed at the earliest stage when the new work activity is being considered. The hazards and risks should be reviewed at each subsequent stage in the development of a new process.

- The purpose of the assessment is to enable an informed decision to be made by employers about the validity of measures to eliminate or minimize risks from chemicals. Employers should show that all aspects of the use of chemicals have been considered in the assessment.

- For complex work activities, such as the manufacture of chemicals, the hazards of the process may be identified by breaking down the process into its component operations; the stages for reviewing risks may include a desk study (a paper review of the process and known risks), laboratory development work, pilot plant operations, commissioning and full operation of plant.

- Hazardous chemicals might be used in quantities which have the potential to be a major risk not only to workers, but also to the population in the vicinity of the use of the chemicals and to the general environment.

1.3. Procedures for assessment

The assessment should be carried out by employers or by persons acting on their behalf that have the necessary Information, instruction and training and are competent to do so. It should include:

- **Assessment of risks**

This should include consideration of which chemicals are used and the nature of their hazards, i.e. whether they may present a risk of one or more of the following:

- ✓ acute or chronic ill health by entry into the body through inhalation, skin absorption or ingestion;
- ✓ injury or ill health from skin or eye contact;
- ✓ injury from fire, explosion or other events resulting from physical properties or chemical reactivity

- **Appraisal of control measures**

An estimate of risk, and whether it can be eliminated, should be made, taking into account the engineering control measures and systems of work.In estimating health risks, account should be taken of exposure limits or other exposure criteria specified, approved or recognised by the competent authority. Personal protective equipment should only be taken into account as a method of control where other measures have been taken but are not sufficient;

- **Action programme**

The estimated risk should be compared with criteria that have been formulated, agreed or recognised by the competent authority for safety in the use of chemicals and a programme of work drawn up based on these established criteria or, where such criteria do not exist, other valid criteria.

- **Control Measures**

Control measures include actions that can be taken to reduce the potential of exposure to the hazard, or the control measure could be to remove the hazard or to reduce the likelihood of the risk of the exposure to that hazard being realized. A simple control measure would be the secure guarding of moving parts of machinery eliminating the potential for contact. When we look at control measures we often refer to the hierarchy of control measures.

- ✓ Eliminate the hazard
- ✓ Substitute the hazard with a lesser risk
- ✓ Isolate the hazard
- ✓ Use engineering controls
- ✓ Use administrative controls
- ✓ Use personal protective equipment

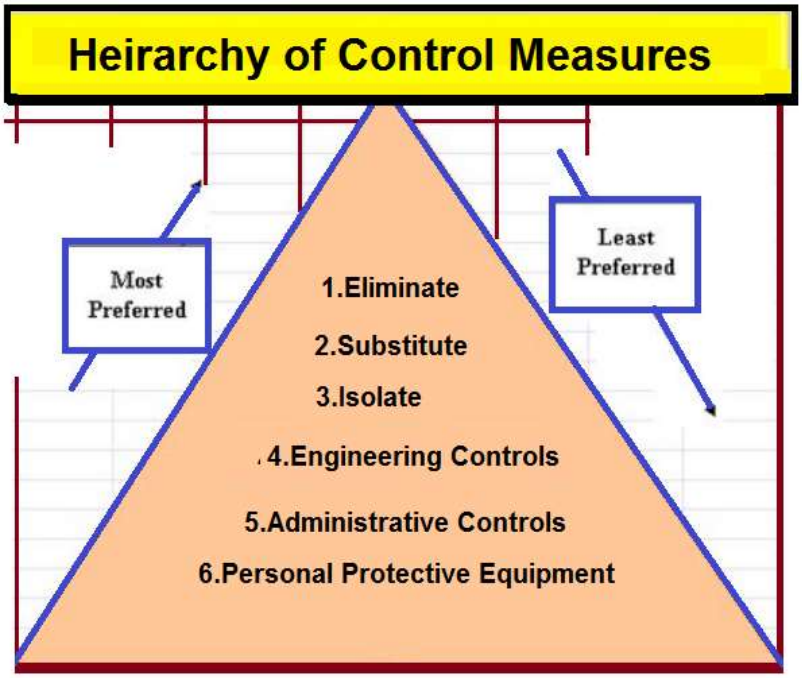

Figure 43: Hierarchy of control measures

- **Effective Planning, Organization, Control, Monitoring and Review**

The Management of Health and Safety at Work Regulations 1999, arrangements should be made for the effective planning, organization, control, monitoring and review of the preventive and protective measures introduced. If five or more people are employed, the arrangements must be recorded in writing. It is important to clearly distinguish between workplace precautions and risk control systems. According to the Health and Safety Executive (HSE) publication Successful Health and Safety Management, workplace precautions are provided and maintained to prevent harm to people at the point of risk. Such precautions can include:

- ✓ deploying appropriate display screen equipment
- ✓ maintaining building fabric to minimize slips, trips and falls
- ✓ guards
- ✓ local exhaust ventilation
- ✓ safety instructions
- ✓ Systems of work.

Risk control systems provide the basis for ensuring adequate workplace precautions are provided and maintained. The three basic stages are:

- ✓ hazard identification
- ✓ risk assessment
- ✓ Risk control.

Following the assessment, measures must be introduced to reduce the risk of injury to the lowest level reasonably practicable. For risk control, the following hierarchy is suggested.

- **Eliminate risks by:**
  - ✓ removing the need for manual handling
  - ✓ substituting use of less hazardous substances
  - ✓ using a better-guarded machine
  - ✓ Avoiding certain activities and processes, perhaps by buying in from sub-contractors.

- **Combat risks at source**.

For example, in a factory environment this may be done by engineering controls and giving collective protective measures priority by:

- ✓ separating operator from hazard through enclosure
- ✓ protecting dangerous parts through guarding
- ✓ designing processes, machinery and activities to minimise the release of airborne hazards or to suppress or contain them
- ✓ machinery which can be operated remotely and which features automatic feeding
- ✓ Preventing lone working.

- **Minimize risks by:**
  - ✓ designing suitable safe systems of work
  - ✓ appropriately training supervisors and managers in the organization's safety culture, i.e. to better identify unsafe practices and prevent them arising again
  - ✓ reducing the need for manual handling
  - ✓ Providing, as a last resort, personal protective equipment and ensuring it is used.

Who is at risk?

Having identified the hazards, it is necessary to identify who is at risk. It is not necessary to identify individuals by name, rather specific groups of employees and others can be resorted to, eg:

- ✓ office workers (including any who are home-based or predominantly mobile, eg sales representatives)
- ✓ production workers
- ✓ assembly line workers
- ✓ maintenance staff
- ✓ cleaning staff
- ✓ security staff
- ✓ managers
- ✓ supervisors
- ✓ building contractors
- ✓ engineering contractors
- ✓ catering contractors
- ✓ drivers and delivery staff
- ✓ warehouse staff
- ✓ visitors
- ✓ General public.

Particular attention needs to be given when vulnerable people are identified, e.g. young workers or new and expectant mothers. Additional controls may be required to reduce the risk to an acceptable level for such employees.

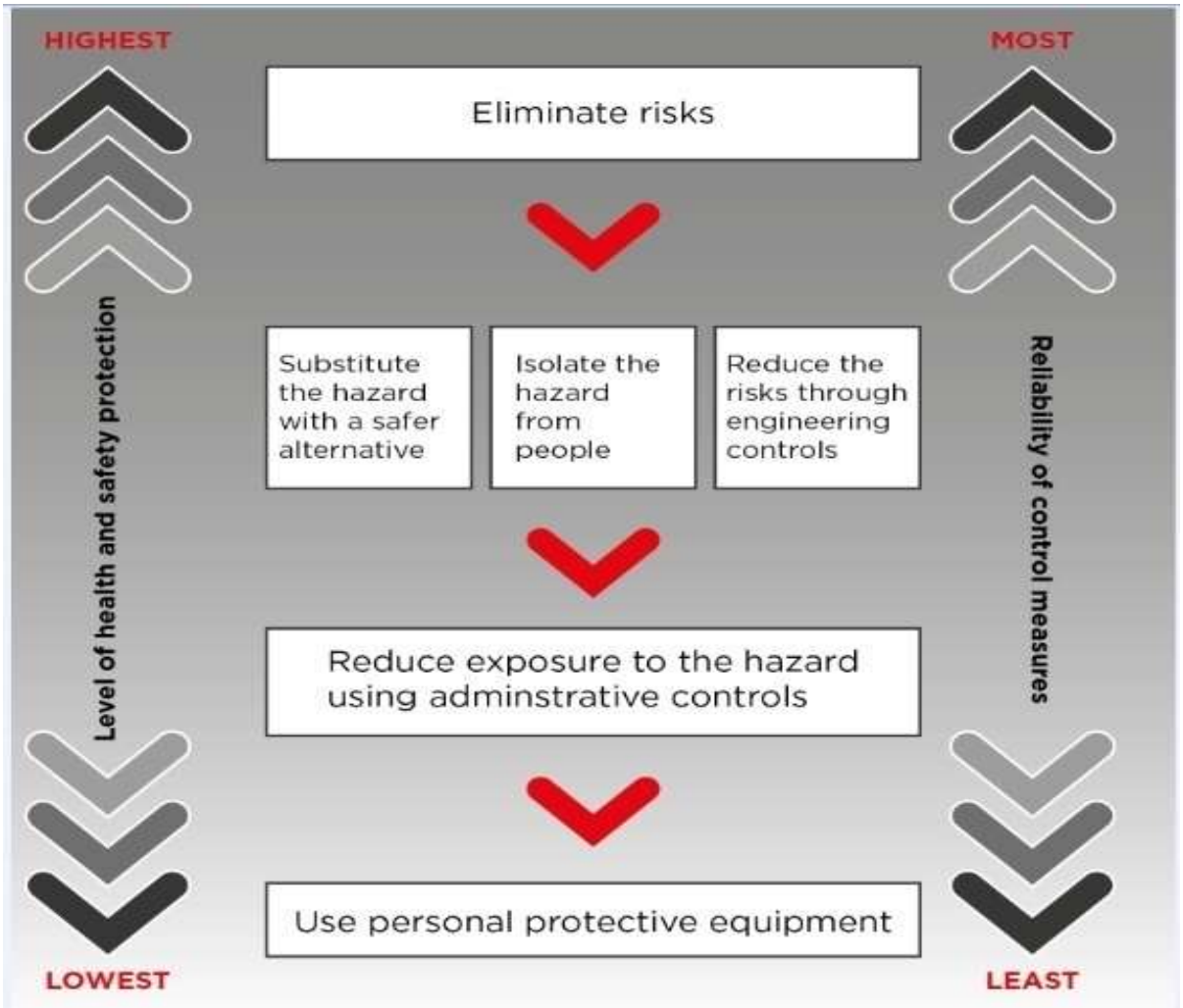

Figure 44: The Hierarchy of control measures

Self-Check – 1	Written Test

Instruction: Follow the below selected instruction

The following are true or false statements, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	To Minimize risks designing suitable safe systems of work
	True or false:
2	Having identified the hazards, it is necessary to identify who is at risk
	True or false:
3	According to the Health and Safety Executive (HSE) publication Successful Health and Safety Management, workplace precautions are provided and maintained to prevent harm to people at the point of risk
	True or false:

Note: Satisfactory rating - 2 points **Unsatisfactory - below 2 points**

2.1 Introduction of cleaning solar panel

The most effective way to clean your solar panels is with a hose and a bucket of soapy water. Essentially, in the same manner you would wash your car at home. Because you don't want to scratch the panels in any way, it's best to use just water and a non-abrasive sponge to apply soapy water.

Solar panels are generally self-cleaning, but in particularly dry areas or where panel tilt is minimal, dust and other substances such as bird droppings can build up over time and impact on the amount electricity generated by a module. This is where cleaning solar panels may have to be done.

Solar panels does not have any moving parts, which is why there`s not a whole lot of maintenance to take care of. However, cleaning is one aspect of solar panel maintenance that should not be taken lightly**. In this article you will learn how to clean solar panels the right way.**

Figure 45: Cleaning solar

- **How to clean solar panels**

Solar panels are generally self-cleaning, but in particularly dry areas or where panel tilt is minimal, dust and other substances such as bird droppings can build up over time and impact on the amount electricity generated by a module. Grime and bird poop doesn't need to cover an entire panel to have an effect. This is where cleaning solar panels may have to be done. And for the longer term, you may be asking "how often to replace a solar panel?"

Figure 46: replace a solar panel

2.2 Cleaning Tips for Solar Panel Cleaning

- Solar panel cleaning kits come in very handy for cleaning solar panels. Inside the kit, you will find a biodegradable soap, a wiper, and a small brush or brush with a longer handle. Mix the soap in the bucket with water. Instructions are provided on the bottle. Dip the brush in the bucket and begin gently wiping the solar panels. You can use plain water or a soft brush to remove any grime or dirt that has built up on the panels.
- How to clean solar panels has never gotten easier! Clean solar panels when they are moist or wet so any dirt so residue that is stuck on them can be wiped off easily.

- Never use an abrasive sponge or soap for your solar panel cleaning as you may scratch the glass. The best way to clean solar panels by using a soft rag or biodegradable soap.
- It is important not to use harsh materials when cleaning solar panels as they could cause damage, and solar panels are costly to repair.
- If you clean often, you might be able to just run a hose along the panels to remove any dirt. Fewer calls on solar panel maintenance.
- For your safety and the safety of others around you, use a long handled wiper to clean the panels while you are standing on the ground.
- If you must get on the roof, take proper care as once you begin cleaning, the roof becomes slippery and you could slide off when you get down, so use safety ropes or a harness for support.
- Always watch out for dirt on the solar panels to make sure it doesn't build up since they can absorb sunlight better when they are free of dirt.
- **How much money would it cost me to neglect solar panel cleaning?**
- It is reasonable to assume that solar panels can lose 15-25% of their efficiency if not cleaned properly. This literally means that they will generate 15-25% less electricity, which you now will have to source from the utility company at their price rates. This easily adds a couple of years extra on the payback time.
- **How often should I clean my solar panels?**
- In most places, there`s more pollution in the winter, which is why the spring is a good time to do an annual cleaning. Solar panels that are cleaned once and twice a year produce 3.5% and 5.1% more electricity respectively than those that are left un-cleaned. However, some places do require extra attention:
- Cleaning solar panels is not really that much different than cleaning a typical window. It is not very time-consuming either. Neglecting to clean your solar panels is not much different than throwing money out of the window. Self-cleaning solar systems are available for those lazy folks out there that are willing to spend the extra buck.

Self-Check – 2	Written Test

Instruction: Follow the below selected instruction

Mach the following question from Column A to B			
No	A		B
	Solar panel cleaning kits	A	The same cleaning a typical window
	best way to clean solar panels	B	with a hose and a bucket of soapy water
	For your safety and the safety of others	C	does not have any moving parts
	Solar panels	D	use a long handled wiper
	effective way to clean your solar panels	E	Soft rag or biodegradable soap.
	Cleaning solar panels	F	handy for cleaning solar panels

Note: Satisfactory rating - 4 points **Unsatisfactory - below 4points**

Information Sheet -3	Connecting control circuits using standard drawing procedures.

3.1 Introduction Control Circuit

A control circuit is used to ensure that the motor is started and stopped in a safe manner for both the operator and the equipment. The thermostat is part of a low-voltage control circuit that controls a relay that actually energizes and de-energizes the power circuit to the air conditioning compressor.

A control circuit is a special type of circuit used to control the operation of a completely separate power circuit. Consider a 1,000 horsepower, large industrial motor driving a water pump. The motor is connected to a high voltage electrical supply of 2,400 volts.

- **Control circuits and auxiliary circuits**

The increasing demands on machines and installations in terms of operational safety and accident prevention require comprehensive measures to protect both man and machine. For example, insulation faults in a control system must not lead to hazardous machine motions. Therefore, when choosing a system type (TN, TT or IT systems) and the associated protective measures, the following aspects are of particular importance:

- ✓ Probability of insulation faults
- ✓ Necessary basic protection and fault protection
- ✓ Continuity of the power supply
- ✓ Technical and commercial aspects
- ✓ Experience regarding secondary effects (fire, downtime costs, etc.)

In the case of electrical machines, this applies to the control circuits and auxiliary circuits as well as to the main circuits. In main circuits, the most important aspects are protection against electric shock, protection of persons and fire prevention. In control circuits and auxiliary circuits, especially those with voltages below the permissible touch voltage of AC 50 V/DC 120 V, the focus is on operational safety.

3.2 Types of Controls:

In ensuing lines we will discuss about the various forms of control circuits and types of devices used in the normal day to day life pertaining to the field of Electrical Engineering.

a. Manual control:

The link between the measuring element and the regulating unit is the human operator. In this type of control no automatic controls are used in the system. This type of system might be very simple to implement but the only drawback being that such a system needs constant human monitoring and vigilance.

b. Semi-automatic controls:

The human operator starts off a sequence of operations which are then carried out automatically in some predetermined manner. For example starting up an electric motor by pressing the start button or in start-up a process in which the valves are operated in a definite sequence at fixed time interval by a timer.

c. Automatic control:

There is no human link between the measuring unit and the regulating unit. Hence the operator is replaced by the controller. This action is continuously variable and remote. Automatic control system is one in which the actual value of the controlled parameter (such as pressure, temperature, flow, level etc) is compared with a desired value and corrective action is taken depending upon the deviation between the two values without the inclusion of a human element. It includes both the measuring means as well as the controlling means and both are done automatically by the system itself, hence the nomenclature.

- **Local control:**

The regulating units are altered by means of a lever, hand wheel or other attachments fixed on the unit itself.

- **Remote control:**

Some means of power transmission is used to connect the regulating unit to an actuating device mounted some distance away. The power transmission may be either through mechanical linkages, fluid linkages or electrical linkages.

- **On/off control:**

The regulating unit occupies only one of the available two extreme positions (as in case of electrical relay or switch). A very common example of this is the normal manual on-off switch that we use in our houses to turn on the lights and turn them off.

- **STEP- by -step control:**

The regulating unit can occupy more than two positions but as the name implies, the action is not continuous and occurs in jerks or steps as in the case of notches on a speed regulator or starter of an electrical motor.

- **Continuously variable control:**

The regulating unit can be at rest in any position between two definite limits as in slider of potentiometer slide wire to convert the vertical, horizontal and angular motion in to the voltage difference to check the set value and operate accordingly.

- **Control devices**

Every control circuit is composed of a number of basic components connected together to achieve the desired performance. The size of the components varies with the power of the motor, but the principle of operation remains the same. Using only a dozen basic components, it's possible to design control systems that are very complex. The basic components are the following:

- ✓ Disconnecting switches
- ✓ Manual circuit breakers
- ✓ Cam switches
- ✓ Pushbuttons
- ✓ Relays

- ✓ Magnetic contactors
- ✓ Thermal relays and fuses
- ✓ Pilot lights
- ✓ Limit switches and other special switches
- ✓ Resistors, reactors, transformers, and capacitors

The ensuing list of Basic Components for Control Circuits illustrates these devices, and states their main purpose and application. Fuses are not included here because they are protective devices rather than control devices. The symbols for these and other devices are given below.

- **Basic components for control circuits**
  - ✓ **Disconnecting switches:**

A disconnecting switch isolates the motor from the power source. It consists of 3 knife-switches and 3 line fuses enclosed in a metallic box. The knife-switches can be opened and closed simultaneously by means of an external handle. An interlocking mechanism prevents the hinged cover from opening when the switch is closed. Disconnecting switches (and their fuses) are selected to carry the nominal full-load current of the motor, and to withstand short-circuit currents for brief intervals.

- ✓ **Manual circuit breakers**:

A manual circuit breaker opens and closes a circuit, like a toggle switch. It trips (opens) automatically when the current exceeds a predetermined limit. After tripping, it can be reset manually. Manual circuit breakers are often used instead of disconnecting switches because no fuses have to be replaced.

- ✓ **Cam switches**:

A cam switch has a group of fixed contacts and an equal number of moveable contacts. The contacts can be made to open and close in a preset sequence by rotating a handle or knob. Cam switches are used to control the motion and position of hoists, callenders, machine tools, and so on.

- ✓ **Push-buttons**:

A pushbutton is a switch activated by finger pressure. AB push buttons, 30mm NEMA Two or more contacts open or close when the button is depressed. Push-buttons are usually spring loaded so as to return to their normal position when pressure is re moved. 4. Mechanical-interlocked push buttons with NO (normally open) and NC (normally closed) contacts; rated to interrupt an ac current of 6 A one million times.

Self-Check – 3	Written Test

Instruction: Follow the below selected instruction

Mach the following question from Column A to B			
No	A		B
1	Control Circuit	A	Power transmission
2	System Type	B	No human link
3	Manual Control	C	Definite sequence at fixed time interval by a timer
4	Semi-Automatic Controls	D	Human operator
5	Automatic Control	E	TN, TT OR IT
6	Remote Control	F	Ensure that the motor is started and stopped in a safe

Note: Satisfactory rating - 4 points **Unsatisfactory - below 4 points**

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