REPUBLIC OF SOUTH SUDAN

TECHNICAL AND VOCATIONAL EDUCATION AND TRAINING
NON FORMAL TVET COMPETENCY BASED CURRICULUM

LEARNER'S BOOK

For

CERTIFICATE OF PROFICIENCY

IN
SOLAR PV SYSTEM AND ELECTRICAL INSTALLATION

SEPTEMBER 2019

DISCLAIMER

This curriculum has been produced by the EMPOWER Project with financial support from European Union. Its contents are the sole responsibility of the EMPOWER Consortium and do not necessarily reflect the views of the European Union.

FOREWORD

Learners are central to the success of any competence-based learning approach. This document is the Learner's Book which has been developed as part of the competence-based learning package of the South Sudan non-Formal TVET Curriculum development assignment. The purpose of this book is to provide essential competence-based learning information to the trainees of the seven priority trades. The document is presented in six sections.

Section one gives general introduction and goes further to give information on learning program, structure, organization of the training course contents, learning strategies in a competency based learning environment and how to use the learner's book. Section two provides for the theory of competence-based learning and its assessment criteria. Section three provides for the competency profile of the Certificate of Proficiency (Level 1) holder and market job opportunities available on successful completion of the training. Section Four gives information on the various learning modules for the trade. Section five gives information on the on-job training during industrial attachment and section six gives the summary notes for theoretical understanding of the various modules theories, trade tools, equipment's and knowledge. This has been provided in the form of learning information sheet.

The competence-based curriculum gives the learners an opportunity for the second chance education through the acquisition of technical and vocational skills. It is my wish to the learners of these curricula to take this life-long journey seriously and make use of the learning opportunities provided to them to be of value addition. These opportunities will enable them acquire skills for direct employment in the relevant industries as well as for self-employment in the practice of trade specific skills.

The Ministry of General Education and Instruction wishes all the users of this Learner's Book the very best in their quest for discovering knowledge through competence-based learning.

Hon. Deng Deng Hoc Yai
Minister of General Education and Instruction

ACKNOWLEDGEMENT

Development of this leaner's guide for Tailoring and Garment making trade has been a consultative process with participation from different stakeholders. The Ministry of General Education and Instruction wishes to thank everyone who played a role in one way or the other in the process of developing this harmonised National Technical and Vocational Skills Competency-Based training learner's guide in Tailoring and Garment making Competency-Based curriculum for South Sudan.

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We wish to appreciate the role played by the Minister of General Education and Instruction, Hon. Deng Deng Yai Hoc, the Minister of Labour, Public Service and Human Resource Development, Hon. James Hoth Mai, the Minister of Culture, Youth and Sports, Hon. Nadia Arop Dudi, for their commitment throughout the entire curriculum development process. Their commitment and visionary messages for strengthening TVET delivery in South Sudan kept the team on course.

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Through this learner's guide, we look forward to a great future in developing Tailoring and Garment making skills for the South Sudan labor market and beyond.

ACRONYMS AND ABBREVIATIONS

AC	Alternating Current
CRO	Cathode Ray Oscilloscope
DC	Direct Current
DSO	Distribution System Operator
ELCB	Earth-Leakage Circuit Breaker
ESD	Electrostatic Discharge
IC	Integrated Circuit
ICT	Information Communication Technology
IEE	Institution of Electrical Engineers
I_{sc}	Short-Circuit Current
IT	Information Technology
KVA	kilovolt-Ampere or apparent power
KVAR	Reactive Power
KW	Kilowatt or Real Power
LCR	Locus Control Region
LM	Lumens
MCB	Miniature Circuit Breaker
MoGEI	Ministry of General Education and Instruction
MoG	Module Outcome Guide
MoLPSHRD	Ministry of Labour, Public Service and Human Resource Development
MTC	Multi-Purpose Training Centre
NGO	Non-Governmental Organization
NRC	Norwegian Refugee Council
NVQF	National Vocational Qualifications Framework
OJT	On-The-Job training (OJT)
OHS	Occupational Health and Safety
PLAR	Prior Learning Assessment and Recognition
PTH	Practical Training hours
PBAX	Private Automatic Branch Exchange
PCB	Printed Circuit Board
PPE	Personal Protective Equipment
PV	Photovoltaic
RPL	Recognition of Prior Learning
SSOPO	South Sudan Older People's Organization
TAR	Training Achievement Record
TTH	Theory training hours
TVET	Technical Vocational Education and Training
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
VOSDO	Vocational Skills Development Organization
V_{sc}	Short-Circuit Voltage
V_{oc}	Open Circuit Voltage
V_{max}	Maximum Voltage
VQF	Vocational Qualification Framework

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1.0 SECTION ONE: INTRODUCTION TO LEARNER'S BOOK

1.1 INTRODUCTION

This learners' book is an information booklet that provides learners of Certificate of Proficiency (COP) in Solar PV system and Electrical Installation trade with the key and strategic information that they need to know as they go about their competency-based learning experiences in the study of Solar PV system and Electrical Installation trade. The curriculum learning experience has been designed such that the trainees learns both at the Intuitional Based Technical and Vocational Education and Training (IBTVET) and Enterprise Based Technical and Vocational Education and Training (EBTVET). The South Sudan Non-Formal Competency based TVET curriculum has been designed to facilitate learning at three places namely, Theory classes at the IBTVET, Practical classes at the IBTVET practical training workshop and practical on job training experience in the place of work within the respective trade industry. This follows the dual system of TVET education.

This document provides learners with the key information about the competency-based learning for the COP in Solar PV system and Electrical Installation trade. It gives the specific objectives for each of the competencies development learning modules as derived from the learning outcomes in the main curriculum training syllabus and the associated Trainers' Guide. The learning activities for each module are reflected in the Learners' Guide only in order to avoid unnecessary repetition and also with the understanding that each activity can only be executed effectively under the guidance of the trainer who is the facilitator of learning.

The document gives a sample revision questions and self-competency assessment questions. These are provided within the Learners' Guide to enable learners to gauge the extent to which they have digested the material associated with each module and learning outcomes as contained in the training syllabus. The learners are advised not to set the limit of their scope of subject knowledge and competence to the few sample questions provided in this booklet. They should read wider so as to gain more knowledge and competencies. This is a lifelong learning journey experience and learners are encouraged to be motivated and learn to learn the skills that will increase their chances of getting sustainable livelihood income support employment within their communities and be motivated to continue with their lifelong learning journey so as to contribute to the attainment of SDG 4 deliverables in South Sudan.

Learning Information Sheet comprising of summarised notes for each unit of the module has been provided in this Learners' book only. The notes in the information sheet are only meant to complement other additional references and reading materials provided by the trainer. Learners are also advised to obtain further reading materials from school/college libraries as well as from the internet and other prescribed text books.

1.2 PRESENTATION OF CERTIFICATE OF PROFICIENCY IN SOLAR PV SYSTEM AND ELECTRICAL INSTALLATION

The specific trade occupation skills that once acquired will lead to the award of Certificate of Proficiency in Solar PV system and Electrical Installation trade. These respective modules have been organised in the form of Modules which are in themselves self-contained complete Basic Employable Skills Training (BEST) programs within the trade of Solar PV system and Electrical Installation.

These modules can be offered and certified on their successful completion as single modules with the exception of module I that cuts across all the trades. The module one covers the issues surrounding specific trade theory, trade tools and equipment, occupational health and safety, fundamentals of trauma awareness, and understanding of competency based learning and its assessment criteria.

The course comprises of nine modules of competencies with each module being a certifiable basic industry employable skill in the practice of occupation of Solar PV system and Electrical Installation. The course aims at formal, non-formal and informal training for persons who wish to acquire the right knowledge, attitude and skills, that will enable them to either engage in salaried employment in the profession of Solar PV system and Electrical Installation operating firms at junior level or be self-employed by managing their own business within the trade of Solar PV system and Electrical Installation.

The course training curriculum has been designed and developed to achieve the objectives of providing multi-skilled workers for the occupation of Solar PV system and Electrical Installation industry in South Sudan and beyond.

1.3 ORGANISATION AND PRESENTATION OF THIS LEARNER'S BOOK

The competency-based learning course for the Certificate of Proficiency in Solar PV system and Electrical Installation comprises of life skills, trade theory, modules of technical competency in Solar PV system and Electrical Installation, workshop practical training skills and on job training industrial attachment.

The course is structured into Core competencies attainment modules and Cross Cutting Skills Modules. Modules are subdivided into Units of Learning specific competencies, which are further sub-divided into Learning Outcomes with assessment criteria. Each module is a comprehensive self-contained employable skills short course training capable of being offered alone. Each modules training has been designed to last for about 80-120 hours.

The course has been designed to allow for practical on-the-job training industrial attachment on completion of each module or with an option of industry attachment at the end of the IBTVET training on all the prescribed modules. The curriculum design provides for post IBTVET training in an EBTVET learning environment. This facilitate the dual system of TVET learning environment.

1.4 LEARNING STRATEGIES FOR A COMPETENCY-BASED TRAINING

Competency-based training delivery is based on the defined competency standards, which are established by the national industry standards or trade occupation standards. The traditional role of a trainer in delivery of this kind of training program changes and shifts towards facilitation and motivation of learning. A facilitator encourages and assists trainees to learn by themselves.

Trainees learn at their own pace. Individual differences are considered. Trainees present themselves for assessment only when they are ready. As trainees learn at different paces, they might well be at different stages in their learning, thus learning must be tailored to suit individual needs of the learners.

1.5 HOW TO USE THIS LEARNER'S BOOK

This is a learner's book and as the name suggests, it focuses on facilitating learners to learn and acquire the desired course competencies. Its aim is to guide the learners in conducting self-paced study that will enable them gain competencies and be certified with the skills for each module and with the entire modules on completion of all the qualifying modules of competency for the Certificate of Proficiency in Solar PV system and Electrical Installation trade.

The aim of this booklet is to guide learners of this important Solar PV system and Electrical Installation skills development program. It gives guidance on the key learning testing questions, competency assessment criteria of self-assessment, formative assessment and summative assessment.

The learner's book also provides information on fundamentals of competency-based learning, and the differences between the traditional knowledge-based approach to Education and competency-based education and training approaches. It goes further to show learners on the key competencies profile for Certificate of Proficiency in Solar PV system and Electrical Installation trade and job profile of the COP holder for the occupation of Solar PV system and Electrical Installation.

1.6 PRESENTATION OF THE LEARNER'S BOOK

The document is presented in six sections with section one providing for the introduction to the learner's book and goes further to give information on the learning program structure, organisation of the training course content, learning strategies in a competency-based learning environment, how to use the learners book and presentation of the learner's book. Section two provides for the theory of competency-based learning and its assessment criteria.

Section three provides for the competency profile of the Certificate of Proficiency holder in Solar PV system and Electrical Installation and market job opportunities available on successful development of the competencies upon completion of the training. Section four gives information on the various learning modules for gaining competencies in the occupation of Solar PV system and Electrical Installation trade. Section five gives information regarding on-the-job training during industrial attachment; and Section six gives the summary notes for theoretical understanding of the various modules theories, trade tools, equipment and Occupational Health and Safety. This has been provided in the form of learning information sheet which appears at the end of this document.

2.0 SECTION TWO : COMPETENCY BASED LEARNING AND ASSESSMENT

2.1 WHAT IS A COMPETENCY-BASED LEARNING APPROACH?

Many learners and stakeholders of TVET learning eco-system have taken their education and learning experience through the use of tradition approach. As such, most people are not familiar with system requirements for effective competency-based learning approaches. This section of the learner's book is meant to provide you with basic answers to some of the most frequently asked questions about competency-based education learning, training, assessment and certification.

The term competency-based education is an approach to designing learning programs with a focus on learners demonstrating that they have attained module specific competencies as a result of going through their respective learning system. These competencies are related to knowledge, skills, attitudes and abilities rather than time spent in a classroom to achieve the competencies.

According to the Competency-Based Education Network (C-BEN) 2017. The term competency-based education combines an intentional and transparent approach to curricular design with an academic model in which the time it takes to demonstrate competencies varies and the expectations about learning are held constant. Learners acquire and demonstrate their knowledge and skills by engaging in learning exercises, activities and experiences that align with clearly defined programmatic outcomes.

Students receive proactive guidance and support from faculty and staff. Learners earn credentials by demonstrating mastery through multiple forms of assessment, often at a personalised pace. Competency-based education therefore is an approach to teaching and learning that clearly identifies the competencies that students must master on a module for them to be declared competent and awarded with module of competency completion certificate. The certificate is issued on a gradual process and upon completion of the entire prescribed modules the learners are awarded with Certificate of Proficiency for that respective trade. Each module is designed to be a basic employable skills training module.

Certificate is issued on the completion of each module because this can be an exit point to some learners who feel that they gained something and would wish to then first get employment to support their livelihood and return later to continue with the acquisition of additional skills through the life-long educational journey experience.

The modern use of competency based approach to education and training concept has its origin in the United States of America in the late 1960s and 70s. Since then, many countries of the world are using the approach in the delivery of their education system and especially in the area of TVET programs. The individual and gradual training module certification received by the learners will later on qualify them for prior learning assessment experience when they wish to join other courses that could have similar modules that they have been trained on and certified to be competent in.

2.2 INFORMATION ON HOW TO CONDUCT COMPETENCY ASSESSMENT

Attainment of competency is undertaken through competency based assessment. There are different kinds of assessment that are administered to the learners of these programs, and the most popular ones are:

Table 2.1 Types of competency assessment and their Description

SNo.	Assessment Criteria	Description
1	**Initial assessment:**	This kind of assessment is taken on the admission to the vocational training centre. Its aim is to engage the occupation of interest and level of trauma based on the learner's background. South Sudan is one of the conflict-affected countries of Africa. The learners being admitted into these programs come from various traumatised backgrounds and experiences. This assessment will help the institution, trainer and the sponsor to gauge the motivation for learning and identify any learning difficulty or challenge likely to be faced by the learners. This assessment will also inform on the need of giving learners numeracy and literacy skills.
2.	**Prior learning experience assessment:**	This is carried out by the teacher who is engaged with the training of the learner. Since learners come from different backgrounds, the aim of this assessment is to establish if the learner had previously acquired some competencies such as through learning on-the-industry job working environment. In such a case, the learner will apply for prior learning experience assessment and if they meet the requirement, then such prior learning experience will be recognised and exempted. The form for this application is provided for in the trainer's guide.
3.	**Self-assessment guide:**	This is done by the learner on completion of each module. If the learner is convinced that he or she is now ready to be assessed, then the learner will inform the trainer that he or she is ready to be assessed. Samples of these self-assessment guides for each module have been developed.
4.	**Formative Assessment:**	This is the assessment provided by the trainer to certify that the learner has attained the competencies. The trainee's performance in the formative assessment will be recorded on the trainee's achievement record. Instructors of this curriculum need to be trained on how to administer a competency-based assessment. This is because in a competency-based learning assessment, the learner is either competent or not yet competent. When assessed and proved competent, then they are awarded with certificate of competency in that respective module or modules. If the assessment result shows that they are not yet competent, then the communication is made to the learner who will repeat the learning on those modules until when they have attained competency and are ready for the assessment. The learning progression is individualised and each learner progresses at his or her own pace

5	**Summative assessment:**	This is done at the end of the training by an external assessor from the industry. In most cases it is done practically when the learners are practicing their acquired skills through on -job training. This curriculum design has provided for 20 hours on-the-job training industrial attachment after each and every module or with an option of taking the on-Job training upon completion of all the prescribed modules. South Sudan needs to put down systems and policies to govern this kind of assessment practice, and there is a need to identify professionals from each trade who can be used to administer this important assignment. This will also require active industry participation. In the absence of these, the trainers might be allowed to use the IBTVET assessment as the country prepares to roll-out this kind of assessment. There is also a great need for this training curriculum to be supported by EBTVET training guide. These will be two. One for supporting the learner; and the other one for supporting the on-job training instructor.
6.	**Competency Attainment Verification:**	This is done both internally and externally by the verifiers to confirm that indeed the competency has been attained by the learners.

2.3 INFORMATION ON CERTIFICATION SYSTEM FOR COMPETENCIES ATTAINED.

Learners who demonstrate the attainment of competencies will be issued with respective modules of competency certificate that shows that the learner has attained the competencies in the respective level of occupation module and modules. There is no certificate being issued for module 1 as it is not an employable skills training. The certification is issued on a module by module basis and there will be gradual certification for each module where competencies have been attained. On completion of all the prescribed modules for the Certificate of Proficiency level training program, the learner will then be awarded with a final competency certification with the issuing of a Certificate of Proficiency in Solar PV system and Electrical Installation.

3.0 SECTION THREE: COMPETENCY PROFILE FOR COP IN SOLAR PV SYSTEM AND ELECTRICAL INSTALLATION TRADE

3.1 COMPETENCY PROFILE

The term competency profile refers to the key learning skills experience areas that trainees of the curriculum program are expected to demonstrate competence in as a proof that they have acquired learning though the occupation learning system and environment. The competence profile informs the formulation of learning outcomes, contents of design of modules of competency, application of Blooms taxonomy learning experience action verbs, self-assessment guide, formative assessment, summative assessment, verification and certification. In this document the competency profile has been classified into 3 categories namely:

1. Core, Technical /functional or hard skills
2. Soft skills or self /personal skills
3. Business skills

The table below shows the competency profiles for holders of the Certificate of Proficiency in Solar PV system and Electrical Installation trade.

Table 2.2 COMPETENCY PROFILE FOR HOLDER OF CERTIFICATE OF PROFICIENCY IN SOLAR PV SYSTEM AND ELECTRICAL INSTALLATION TRADE.

Technical competencies	Soft skills competencies	Business skills
1. Perform basic Solar PV system inspection's. 2. Basic skills for the foundation of electrical installation and practice in the Solar PV system and Electrical Installation Work Environment. 3. Perform basic electrical installation and maintenance 4. Perform Solar PV systems maintenance. 5. Perform off-grid solar pv systems maintainer in an Solar PV system and Electrical Installation Environment. 6. Preform basic Domestic electrical appliances repairer and maintenance	1. Manage interpersonal communication 2. Self-Trauma awareness, assessment and management skills 3. Skills for Managing and dealing with a difficult and complaining customer 4. Environmental safety awareness in Solar PV system and Electrial Installation. 5. Knowledge of basic equipment and tools for Solar PV system and Electrical Installation works. 6. Knowledge of basic Occupational Health and Safety for Solar PV system and Electrical Installation work environment. 7. Knowledge of sources of risks and their prevention in Solar PV system and Electrical Installation practice. 8. Learning to learn and self-study skills for the occupation of Solar PV system and Electrical Installation.	1. Solar PV system and Electrical Installation site Assistant worker and Store keeper 2. Perform basic Customer care services in Solar PV system and Electrical Installation. 3. Self-entrepreneur in Solar PV system and Electrical Installation 4. Knowledge of Solar PV system and Electrical Installation Sites Business information and records keeping 5. Team player in the Solar PV system and Electrical Installation practice 6. Perform first aid and handle personal protective devices

3.2 POTENTIAL LABOR MARKET JOB OPPORTUNITIES

The holder of Employability and Life skills module will be able to do the following jobs in the market:

- ◊ Assistant Solar PV system and electrical site worker.
- ◊ Assistant Sales person of Solar and Electrical equipment's
- ◊ Assistant Solar PV system Installer
- ◊ Assistant Solar PV system Maintainer
- ◊ Assistant solar PV system Off Grid Repairer

4.0 SECTION FOUR: SYLLABUS FOR TRAINING IN COP IN SOLAR PV SYSTEM AND ELECTRICAL INSTALLATION SKILLS MODULE

4.1 TRAINING MODULES FOR SOLAR PV SYSTEM AND ELECTRICAL INSTALLATION

Table 4.1: Modules of competency for solar pv system and electrical installation

CODE	MODULES	TOTAL HOURS	ON THE JOB TRAINING HOURS
4.1	TRADE THEORY, TOOLS, SAFETY AND EQUIPEMENTS	80	20
4.2	FOUNDATION OF ELECTRICAL INSTALLATION AND PRACTICE	90	20
4.3	ELECTRICAL INSTALLATION AND MAINTENANCE	90	30
4.4	SOLAR PV SYSTEMS MAINTAINANCE	90	30
4.5	OFF-GRID SOLAR PV SYSTEMS MAINTAINER	90	30
4.6	DOMESTIC ELECTRICAL APPLIANCES REPAIRER AND MAINTAINER	90	30
TOTAL		**530**	**160**

4.2 MODULE 4.1: TRADE THEORY, SAFETY, TOOLS AND EQUIPMENT'S

Table 4.2: Trade theory, Safety, tools and equipment's Module

A:MODULE CODE	**4.1**	**TTH** **24**	**PTH** **56**	**OJT** **20**
B: UNITS OF MODULE				
Unit of Learning 4.1.1: Trade theory, Tools and Safety in Solar PV System and Electrical Installations On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements: 4.1.1.1 Describe Trade theory in Solar PV System and Electrical Installation 4.1.1.2 Understand the essence of occupational safety and health 4.1.1.3 Identify and explain hazards associated with electrical and Solar PV systems 4.1.1.4 Explore the basic principles and techniques of accident prevention and safety measures 4.1.1.5 Apply First Aid procedures 4.1.1.6 Explain basic provisions for occupational safety and health under South Sudan legislation 4.1.1.7 Understand ecosystem 4.1.1.8 Relate pollution to the environment 4.1.1.9 Describe energy conservation 4.1.1.10 Explain the relationship between society and environment 4.1.1.11 Exhibit knowledge on trade tools and equipment's used in the practice of Solar PV System and Electrical Installation				
Unit of Learning 2.1.2: Basic Computer Skills Applications 1. Explain the different types of hazards and way to minimize them. 2. Discuss the importance of maintaining a clean and safe working environment. 3. State the importance of first aid kit at the work place. 4. Predict possible emergency cases that may happen in an Electronic workshop. 5. Describe different wastes produced in the field of Electronic and telecommunication and its management. 6. Explain the danger and safety signs importance. 7. State the organizational safety and health protocol 8. Interpret South Sudan regulations on occupational health and safety 9. State the advantages of waste separation				
Learning and teaching Resources Required Assessment Method	• Course training curriculum • Learner's guides • Students Guides • South Sudan Vocational qualification framework for level descriptors • Competency assessment guides • Workshop • Trade tools and Equipments			
Assessment Method	• Oral and Written • Performance Assessments and Observation. • Assessment of group work (small manageable groups) • Simulation where necessary			

4.3 MODULE 4.2: ELECTRICAL AND SOLAR PV SYSTEM INSTALLER

Table 4.3: Foundation of Electrical and Solar PV System Installer

A:MODULE CODE	4.2	TTH	PTH	OJT
Module level	**1**	**24**	**54**	**20**
B: UNITS OF MODULE				

Unit of Learning 4.2.1 Electrical Concepts
On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:
4.2.1.1 Demonstrate knowledge of electron theory
4.2.1.2 Distinguish current flow
4.2.1.3 Define conductor, semi-conductor and insulator
4.2.1.4 Apply Ohm's law for DC circuits
4.2.1.5 Indicate factors affecting resistance of conductors

Unit of Learning 4.2.2 Electrical Symbols
On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:
4.2.2.1 Identify electrical symbols and their units of measurement

Unit of Learning 4.2.3 Identify Hazards associated with Electricity
On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:
4.2.3.1 Apply the protection procedures for electric shock
4.2.3.2 Identify safety signs and symbols associated with electricity hazards

Unit of Learning 4.2.4 Describe Sources of Electricity Generation
On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:
4.2.4.1 Identify sources of electricity generation
4.2.4.2 Describe nature of electricity (AC or DC) produced by different sources

Unit of Learning 4.2.5 Calculate Electrical Variables

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.2.5.1 Demonstrate knowledge of series-, parallel-, and series/parallel electrical circuits

4.2.5.2 Calculate electrical quantities in DC circuits based on Ohm's Law

4.2.5.3 Calculate electrical quantities in AC circuits based on Ohm's law

Unit of Learning 4.2.6 Perform Measurements in Electrical Circuits

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.2.6.1 Identify digital and analogue instruments

4.2.6.2 Measure current and voltage in DC circuit

4.2.6.3 Measure frequency of grid electricity

4.2.6.4 Measure real and apparent power

4.2.6.5 Measure voltage and frequency of single and three phase grid electricity

Unit of Learning 4.2.7 Describe Resistive, Inductive and Capacitive Loads

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.2.7.1 Define resistance, capacitance and inductance

4.2.7.2 Differentiate between resistive, inductive and capacitive loads

4.2.7.3 Explain importance of electrostatic discharge (ESD

Unit of Learning 4.2.8 Describe Basic Magnetic Principles

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.2.8.1 Define permanent and temporary magnets

4.2.8.2 Define the term 'flux'

4.2.8.3 Describe magnetic lines of force and list their characteristics

4.2.8.4 Apply the fundamental laws of magnetism

4.2.8.5 Magnetic properties of different material

Unit of Learning 4.2.9 Making Electrical Joints

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.2.9.1 Make

- eyelet joint
- Make crimp joint
- clamp joint
- bolt/screw joint
- twisted joint
- Tee joint
- married joint

4.2.9.2 Carry out soft soldering

Sample Questions

1. Understand basic electrical concepts
2. Outline and explain electrical symbols and their units of measurement
3. Identify hazards associated with electricity and the protection procedures for electric shock
4. Investigate sources of electricity generation
5. Differentiate between AC and DC
6. Calculate electrical quantities in DC and in AC circuits based on Ohm's law
7. Explain how to perform measurements in electrical circuits
8. Define and differentiate between resistive, inductive and capacitive loads
9. Apply basic magnetic principles
10. List characteristics of magnetic lines of force
11. Demonstrate procedure of making electrical joints

Resources	**Non-Consumable** • Oscilloscope • Digital clamp meter • Generator • Oscilloscope • Analogue meter • Analogue voltmeter • Animation of atomic model • Animation of states of matter • Screw drivers, measuring tools, tape-measure, connecting wire, power source, calculator • Soldering iron, soldering gun, solder sucker, blow lamp, pot and ladle, safety goggles, safety gloves, safety boots, overalls	**Consumable** • Clamp meter • Digital Multimeter • Electric fan • Electric heater • Permanent and temporary magnets • Watt meter • VAR meter • Power factor meter • Atomic model • Balloon • Batteries • Conductor • Coils • Solder wire, flux, insulation tape, waste cloth, kerosene, paper, pen, white board, flip charts
Assessment Method	• Oral • Written • Performance Assessments and Observation. • Assessment of group work (small manageable groups) • Simulations • Observation	

4.4 MODULE 4.3: ELECTRICAL INSTALLATION AND MAINTENANCE

Table 4.4: Electrical Installation and Maintenance Module

A:MODULE CODE	4.3	TTH 30	PTH 70	OJT 20
B: UNITS OF MODULE				

Unit of Learning 4.3.1 Plan and Prepare Installation

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.3.1.1 Identify and interpret safety and other regulatory requirements
4.3.1.2 Identify and select the tools and equipment for work
4.3.1.3 Interpret circuit diagrams
4.3.1.4 Explain the purpose of selection and termination of electrical cables
4.3.1.5 Arrange earthing
4.3.1.6 Determine location for solar system and sizing of PV
4.3.1.7 Demonstrate the setting of PV module angles
4.3.1.8 List the tools required for installation of solar panels

Unit of Learning 4.3.2 Assemble and Install Products

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.3.2.1 Confirm assembling and installation specifications
4.3.2.2 Assemble and connect electrical circuit with ports
4.3.2.3 Joint cables and connections
4.3.2.4 State the reason for termination of cable and electrical accessories
4.3.2.5 Demonstrate the procedure for connecting PV panels and electrical components
4.3.2.6 Demonstrate procedure for earthing

Unit of Learning 4.3.3 Test for Operation of Devices

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.3.3.1 Explain the purpose of final quality inspection
4.3.3.2 Test and adjust component and/or parts
4.3.3.3 Demonstrate product knowledge to customer
4.3.3.4 List the reason for quality inspection
4.3.3.5 Complete work-related documents

Unit of Learning 4.3.4 Domestic Installation		
On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements: 4.4.4.1 Erect PVC conduits 4.4.4.2 Erect galvanized steel conduits 4.4.4.3 Install lighting point controlled from one-way switch 4.4.4.4 Install lighting points controlled from one (1) one-way, two-gang switch 4.4.4.5 Install lighting points controlled from two(2) two-way switches 4.4.4.6 Install lighting points controlled by two(2) two-way switches and one intermediate switch 4.4.4.7 Install radial circuit 4.4.4.8 Install ring circuit 4.4.4.9 Describe earth connections 4.4.4.10 Perform Earthing of an installation		
Sample Questions 1. Identify and interpret safety and other regulatory requirements 2. Interpret circuit diagrams used in maintenance 3. Explain the purpose of selection and termination of electrical cables 4. Demonstrate how the setting of PV module angles are set 5. List the tools required for installation of solar panels 6. Demonstrate the procedure for connecting PV panels and electrical components 7. Demonstrate procedure for earthing 8. Explain the purpose of final quality inspection 9. Demonstrate how to Erect PVC conduits 10. Demonstrate how to install lighting point 11. Demonstrate procedure of installing various circuit		
Resources	**Non-Consumable** • Personal protective equipment • Pliers • Side cutter • Wire striper • Screw drivers • Hacksaw • Bench wise • Earth meter • Earthing rod • Magnetic compass • Clamp meter • Metal fra me • Drill machine • Metal support • Radiation meter • Solar panel • Invertors • Dry batteries • Clamps • Cable tie • Mega meter • Earth test meter • Series board • Phase tester • Oscilloscope • Ladder / scaffolding	**Consumable** • Handouts • Switches • Fuses and circuits breakers • Conduits • Wire and cables • Technical drawing • Insulation tape • Cable striping knife • Soldering iron • Soldering bit • Connectors • Ladder / scaffolding • Diodes and Transistors • Distilled water • Bolts and nuts • Diodes and Transistors • Connectors • Measuring tools, tape-measure, voltmeter, ammeter, ohmmeter, multi-meter, connecting wire, power source, calculator • Soldering iron, soldering gun, solder sucker, blow lamp, pot and ladle, safety goggles, safety gloves, safety boots, overalls
Assessment Methods	• Oral • Written • Performance Assessments and Observation.	• Assessment of group work (small manageable groups) • Demonstration • Simulation • Observation

4.5 MODULE 4.4: SOLAR PV SYSTEM MAINTAINER

Table 4.5: Solar PV System Maintainer Module

A:MODULE CODE	4.4	TTH 30	PTH 70	OJT 20
B: UNITS OF MODULE				

Unit of Learning 4.4.1: Demonstrate Diagnostic Procedures

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.4.1.1 Explain the purpose of visual inspection
4.4.1.2 Demonstrate procedure for implementing testing
4.4.1.3 Demonstrate testing procedures for solar system
4.4.1.4 Implement troubleshooting procedures and identify fault
4.4.1.5 State the reason for electric shook when touch charged capacitors

Unit of Learning 4.4.2: Remove Faults

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.4.2.1 Identify the repair or replace component parts
4.4.2.2 Carry out operational testing
4.4.2.3 Explain the reason for short circuit and leakage current
4.4.2.4 Identify the fault-finding techniques

C: Sample Questions

1. Visual inspection
2. Troubleshooting
3. Electric shook
4. Self-study sources

Learning/ Training Resources	**Non-Consumable** • Oscilloscope • Multimeter • Earthing meter • Mega meter • Multi media • Projector • Dice • Sound system • White Board	**Non-Consumable** • Safety Hazards • Insulation tape • Serial port • Pliers • Screw drivers • Spanners • Wire cutter & stripper • AC / DC wires • Batteries • Invertors • Hydrometer • Compass • Nuts and bolts • Flip Chart • Writing pad • Lead pencil • High lighter • White board marker
Assessment Methods	• Oral • Written • Performance Assessments and Observation. • Assessment of group work (small manageable groups)	

4.6 MODULE 4.5: OFF-GRID SOLAR PV SYSTEM MAINTAINER

Table 4.6: Off-Grid Solar PV System Maintainer Module

A:MODULE CODE	4.5	TTH 30	PTH 70	OJT 20
B: UNITS OF MODULE				
Unit of Learning 4.5.1: Describe the Benefits of PV Systems On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements: 4.5.1.1 Explain the advantages of solar power 4.5.1.2 Explain the disadvantages of solar power				
Unit of Learning 4.5.2: Outline PV System Fundamentals On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements: 4.5.2.1 Define the term 'solar radiation' 4.5.2.2 Define the term 'photovoltaic effect' 4.5.2.3 Understand operation of a basic PV system				
Unit of Learning 4.5.3: Describe Off-Grid PV Systems On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements: 4.5.3.1 Define the term 'on-grid' and 'off-grid' PV system 4.5.3.2 Demonstrate knowledge of off-grid PV systems 4.5.3.3 Identify PV components and describe their function in an off-grid system				
Unit of Learning 4.5.4: Maintain Off-Grid PV Systems and Components On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements: 4.5.4.1 Interpret circuit diagram for off-grid operation 4.5.4.2 Outline safety measures associated with PV system maintenance 4.5.4.3 Replace or repair faulty parts or components				
Sample Questions 1. PV systems 2. Sunlight 3. Radiation 4. Photovoltaic effect 5. DC cables 6. Load requirements 7. Mounting structure 8. Combine box 9. Drawings and Symbols interpreted 10. Specifications according to condition of tools and test equipment				
Learning/ Training Resources	**Consumables** • Stationary • Relevant Book • Steel Scale • Pencil • Eraser	• Pointers • Highlighter		
Assessment Methods	• Oral • Written • Performance Assessments and Observation. • Assessment of group work (small manageable groups)	• Simulation • Observation • Demonstration		

4.7 MODULE 4.6: DOMESTIC ELECTRICAL APPLIANCES REPAIRER AND MAINTAINER

Table 4.7: Domestic Electrical Appliances Repairer and Maintainer Module

A:MODULE CODE	4.6	TTH	PTH	OJT
Module level	I	36	84	0

B: UNITS OF MODULE

Unit of Learning 4.6.1: Introduction to Electrical Practice
On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:
4.6.1.1 Practice basics of electricity and Electrical Cables
4.6.1.2 Demonstrate knowledge of basic terms in electrical practice
4.6.1.3 Identify electrical meters and their applications
4.6.1.4 Demonstrate knowledge of basic electronic components and their application

Unit of Learning 4.6.2: Repair Power Supply
On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:
4.6.2.1 Maintenance of power supply

Unit of Learning 4.6.3: Repair Steam Iron
On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:
4.6.3.1 Steam iron maintenance

Unit of Learning 4.6.4: Repair Electric Rice Cooker
On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:
4.6.4.1 Electric rice cooker repair

Unit of Learning 4.6.5: Repair Electric Kettle
On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:
4.6.5.1 Electric kettle repair

Unit of Learning 4.6.6: Repair Mixer and Grinder
On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:
4.6.5.1 Mixer and Grinder Repair

Sample Questions

1. Explain the semiconductor theory, P – N junction theory and diode symbol
2. Demonstrate how to test a diode:
- Construct half wave rectifier
- Construct full wave rectifier
- Construct bridge rectifier
3. Have the trainees develop the circuit diagrams?
4. Create a problem in the circuits and have trainee troubleshoot the problem.
5. Discuss:
- Types of semiconductors
- Selection of type of rectifier circuit for particular application
- Application of capacitors for smoothing

6. Explain the basic structure of a junction transistor, NPN and PNP. 7. Describe the amplification features of a transistor. 8. Demonstrate how to connect a transistor in 'Common base'. 9. Demonstrate how to perform soldering. 10. Discuss • Types transistors • Transistor biasing • De-soldering techniques 11. Explain the operation of a silicon-controlled rectifier, triac and diac. 12. Describe the main application areas of silicon-controlled rectifiers. 13. Demonstrate how to de-solder components. 14. Discuss • Semiconductor theory • Power control using SCRs 15. Evaluate how a photo-switch circuit works 16. Draw a circuit diagram to show how the photo-switch circuit can have connected to a low voltage motor or bell 17. Demonstrate the application of different types of photosensitive circuits. 18. Discuss: • Photo sensitivity • Using photo sensitive devices to control other circuits • Safety requirements 19. Explain difference between analogue and digital ICs 20. Elaborate the advantages of using ICs instead of discrete components. 21. Give examples of analogue ICs commonly used in electronics circuits 22. Discuss: • Integrated circuits • Methods of connecting integrated circuits		
Learning/Training Re-sources	• Bench work, Computer, Projector, Whiteboard, Marker, Duster, Text books, Lecture notes • Papers, Internet • Brush, Electrician toolkit, Drilling machine, Tools and spanner sets, Crimping tool with • Crimping bits all required sizes, Pipe bend and threading machines, Continuity Tester, Phone handset, PBAX, Programming Software tools, Digital phone, Books - Internet - User's manual - Service manual - Journals - Cleaning tools and materials	
Teaching Methodology	• Practical demonstration • Self-paced instructions • Group discussion	
Assessment Methods	• Oral • Written • Performance Assessments and Observation. • Assessment of group work (small manageable groups) • Simulation • Observation • Demonstration	

5.0 SECTION FIVE: ON JOB TRAINING INDUSTRY ASSESSMENT SHEET

5.1 ON JOB TRAINING INDUSTRIAL ATTACHMENT GUIDE

Table 5.1 Industrial Attachment Guide

Module Code:	All modules practical on the job training industrial attachment assessment	
Module Level:	1	
Total Hours:	160	
Prerequisite	Modules of Level 1	
Learning Outcomes	**Performance Criteria**	**Assessment Criteria**
4.7.1 Installation Tools	4.7.1.1 Exposure to tools for solar installation 4.7.1.2 Observation of safety at work place 4.7.1.3 Involvement in workshop activity	• Direct observation • Practical demonstration
4.7.2 Electrical/Electronic components	4.7.2.1 Exposure to electronic tools 4.7.2.2 Observation of safety at work place 4.7.2.3 Involvement in workshop activity	• Direct observation • Practical demonstration
4.7.3 Solar panels	4.7.3.1 Experience in handling solar panel 4.7.3.2 Storage and transportation of solar panels 4.7.3.3 Utility of solar installation equipment and tools 4.7.3.4 Participation in solar installation and maintenance	• Direct observation • Practical demonstration
4.7.4 Participate in Electrical installation project	2.6.1.1 Installation Practice	• Direct observation • Practical demonstration
4.7.5 Participate in solar installation project	4.7.5.1 Maintenance practice	• Direct observation • Practical demonstration
4.7.6 Documentation	4.7.6.1 Keeping records of daily activities	• Oral Questioning, • Presentations by trainees,
Session assessment will be adopted and the following guidelines should be followed regarding Industrial attachment marks; 1. Participation 25% 2. Attendance 10% 3. Time Management 10% 4. Log book: 15% 5. Safety 5% 6. Communication skills 5% 7. Creativity 5% 8. Customer care 5% 9. Cleanliness and hygiene 5% 10. Readiness to be corrected 5% 11. Team work 5% 12. General conduct 5%		
Internal Evaluation: Total internal marks are 100. Marks shall be awarded at the end of every module of the attachment		

Learning/Teaching Resources

Major Equipment/Materials with specification :

1. CRO (Analog/ DSO),
2. Multimeter (Analog/ Digital)
3. Soldering and Desoldering Station
4. Different types of electronic and electrical cables, connectors, sockets, terminations.
5. Various analog and digital ICs
6. Neon tester 500 V.
7. Screw driver set (set of 5)
8. Insulated combination pliers 150 mm
9. Insulated side cutting pliers 150 mm
10. Long nose pliers 150 mm
11. Soldering iron 25 W. 240 V. with solder materials
12. Electrician knife
13. Tweezers 100mm
14. Soldering Iron Changeable bits 10 W
15. De- soldering pump
16. Crimping tool (pliers)
17. Allen key set (set of 9)
18. Magnifying lenses 75mm with illumination
19. Continuity tester
20. Dual DC regulated 15-0-15V, 2 Amp
21. LCR meter (Digital)
22. Signal Generator, 0-100 KHz
23. Battery Charger
24. Digital and Analog IC Tester
25. General purpose PCBs, bread board, MCB, ELCB
26. Clip on ammeter
27. RF Power meter
28. Field strength meter
29. Air Blower (500 Watt)
30. Invertor
31. Charge regulator

6.0 SECTION FIVE: LEARNERS INFORMATION SHEET

6.1 OCCUPATION HEALTH AND SAFETY

Injury can occur when:

- Live electrical parts are exposed and can be touched;
- Metalwork, which is meant to be earthed, becomes live at a dangerous voltage. It is more likely voltages are often exposed. You can minimize this risk if testing is done while the equipment is isolated from any dangerous source of supply, although this is not always possible. Take care to prevent contact with any hazardous internally produced voltages.
- Electric shock causes the most serious injuries. The effects of a shock are largely unpredictable and can easily lead to a fatal injury. However, there is also a risk of burn injuries from arcing when conductors are accidentally short-circuited. Another risk can be harm caused by a person reacting to an electrical injury, e.g. falling from an access ladder or being traumatized by the experience.
- Electric shocks occur when contact with a live conductor causes sufficient current to pass through the body to cause an injury. As a rough guide, voltages exceeding 50Vac or 120V ripple-freed care hazardous in a dry, unconfined, non-conductive location. These voltage values must be reduced if the location is wet or confined or conductive, so where there is an adverse environment, those in charge of the work and those doing the work should be aware of the probable increase in injury risk.
- In some equipment, e.g. microwave ovens, voltages of several thousand volts are used and there is a very high risk of fatal injury if the exposed conductors are touched. Currents as low as 5mA or stored charges can also cause injury. You must take suitable precautions to prevent contact with stored charges in excess of 350mJ.
- If the skin is pricked or cut at the point of contact, the shock current (and so the seriousness of the injury) will be higher. Healthy skin may also become damaged at the time of contact, either by the burning effect of the current or by penetration from sharp-ended conductors.

Carrying out a risk assessment:

You must carry out a risk assessment before testing begins, to help you to identify the measures to take. Consider the following when assessing the risk of injury from electrical testing work:

- The level of voltage, charge or current;
- The nature of the environment.

You also need to think about the hazards present, who may be harmed and how, and the effectiveness of existing precautions. Bear in mind the factors in the bulleted list that follows, which might increase the risk

Some questions to ask when carrying out the risk assessment are:

- Can the work be done with the equipment dead or energized at a safe voltage or current?
- Is it necessary for someone to be working on or near to equipment that is live at dangerous voltages or current levels?
- What is the maximum voltage on conductors that will be exposed during the work activity?
- Are the testers competent? Are they adequately trained and knowledgeable, or have sufficient experience to carry out the work without risk to themselves and others?
- If the testers are not considered fully competent, are they adequately supervised?
- Are the testers able to supervise the working area sufficiently and at all times, to prevent danger to others?
- What physical safeguards should be applied to the

equipment under test to prevent injury, e.g. the use of temporary or permanent screens?

- Is the test instrumentation safe? Has it been properly maintained?
- Do you need to set up a permanent test area separate from the rest of the workplace, where equipment can be taken for testing? Do you need to set up a temporary test area around the equipment?
- Where testing is part of an 'aftersales service' how much must be done at customers' premises? If testing is being done in a customer's home, what special precautions are required to protect the tester and others?
- If the testers design, manufacture or use any special test equipment, does it meet BSEN61010–1?
- How big is the unit under test and how much space is required around it to undertake the testing in a safe and unconfined manner?
- Are all the other workshop employees competent to avoid danger if they need to approach the equipment? If not, how can you make sure they don't?
- Will the equipment be left unattended while live, e.g. while being 'soak tested'?
- Does the workbench or separate area require a warning, e.g. a light, to show that testing is in progress?
- Do you need additional emergency switching devices for other employees to use to reduce the degree of injury to testers? Can residual current devices (RCDs) be used to provide supplementary protection? (Note that this guidance and the complementary information sheets refer to RCDs or 30mARCDs. See 'Residual current devices' for a fuller explanation.)
- Is it possible to reduce the number of available paths to earth to reduce the likelihood of a phase-to-earth shock, e.g. by using barriers, screens and insulating mats?
- Is it possible to use unreferenced supplies, e.g. isolating transformers/batteries, to reduce the likelihood of a phase-to-earth shock?

An assessment of first-aid needs must be carried out. Due to the hazards involved in your workplace, it is likely that this would have identified the need to provide first aiders to give immediate help to casualties at all times. First aiders should have had suitable training, have an appropriate qualification and remain competent to perform their role.

Make a record of the significant findings from your risk assessment: the hazards, how people might be harmed and what controls you have in place to control the risks. If you have fewer than five employees, you do not have to write it down, but it is useful to do this, so you can review it later. You must ensure that you tell those carrying out the testing about the risks you have identified and what action they must take to control them. If you have five or more employees, you

are required by law to record your risk assessment.

Managing electrical testing:

You must provide a safe working environment and establish a safe system of work for your employees (see 'Safe systems of work'). The results of your risk assessment will help to identify the steps you need to take to do this. Employees must co-operate and take reasonable care for their own and other people's safety while they are at work. Consider the following advice for all activities involving testing.

Provide information before carrying out any testing, you must provide information, so that all workers (including any relevant third parties, e.g. those attending witness tests):

- Understand that the risk of electric shock injury will still remain during the testing process, even with the use of earth-free test are a sand/or isolating transformers and/or RCDs;
- Fully understand the scenarios in which these electric shock injury risks can arise in a particular workplace(s).

In addition, it is recommended that employees receive adequate first-aid training, including cardiac pulmonary resuscitation (CPR) skills.

Permanent test areas

These areas:

- Must be under the control of a responsible person;
- Must have adequate space, access and lighting, including clear working space and good housekeeping arrangements;
- Should be accessible during testing only to authorized employees or people working under their direct supervision–this may include an area set apart by barriers to prevent entry;
- Should have warnings, as determined by your risk assessment, e.g. warning signs at the entrance, warning lights indicating that testing is in progress and other such lights to indicate when it is safe to enter the area (duplicate red and greenlights are often used);
- Should have emergency stop push buttons or equally effective means to cut all test supplies if there is an emergency. These emergency controls should be prominently identified. (Note that the emergency controls should not remove supplies to the general lighting in the area.)
- Should, where necessary, provide first-aid information e.g. display an electric shock poster, e.g. Electric shock: First aid procedures, at prominent locations, showing emergency arrangements, especially telephone numbers.

Temporary test areas

In some situations, it may not be possible to remove equipment to a permanent test area, e.g. because the equipment is too large for the test bay or is located at the customer's premises. If live testing needs to be carried out, setup a temporary test area around the equipment, and take the precautions listed above for permanent test areas. If it is not practicable to do this, make an assessment of what precautions are needed to reduce that risk to a slow a level as possible.

Remember that simple 'Go/No go 'plug-in socket testers will in general only provide a polarity check and an indication that an earth may be present, but not its effectiveness.

Earth-free areas

Make a test area as earth free as possible, in conjunction with the use of isolated supplies. To achieve this, take the following precautions:

- Use a test bench made of insulating material with shrouded legs and framework to prevent the possibility of contact with earth while testing;
- Remove all pipes, radiators, structural steel work, metal conduits, earthed electrical appliances, metallic socket outlets etc. from within reach of the test bench, or permanently shroud them with insulating material to prevent contact;
- Where soldering irons and task lighting are needed, they should be extra low voltage, supplied from an isolating transformer to prevent the need for earthed metal at the test area;
- If a television or radio aerial socket is needed at the test area, it should be isolated,
- Provide insulating rubber matting on the floor, keep it clean and dry and test it regularly. It should

be large enough for the test operative to remain on it whether standing or seated during testing (note that chair legs may damage the matting);

- If electrostatic discharge wrist straps are provided, these must incorporate a suitable resistance (typically 1 Megohm or more). Using a wrist strap, which directly connects the wearer to earth, is not permissible.

Supplies to equipment under test

Provide each item of equipment under test with its own test supply. These supplies should be from designated sockets or terminals provided with covers, interlocked with the supply isolator. The supplies should have suitable system protection against overload and overcurrent in the event of faults e.g. fuses.

Note that:

- Where an isolating transformer is used for the supply to the equipment under test, a separate transformer be available as test bench. If this is not reasonably practicable, the same isolating transformer may be used for supplies to alternate benches, provided the risk of referencing this supply to earth at any bench is properly controlled and the transformer does not then have an unacceptably high leakage current;
- The supply from the isolating transformer should be provided from a single socket outlet and clearly marked 'only for use for making live equipment under test'. No fixed wiring should be connected to the earth terminal of the outlet socket. The faceplate of the socket should be made of insulating material. There must be no unnecessarily exposed live parts on equipment under test;
- In certain circumstances Class I equipment under test must be effectively earthed unless supplied via an isolating transformer. This will bring with it an increased risk of electric shock, which may be minimized by using other precautions.
- When the equipment under test is Class I, any pre-existing earth fault must be detected and corrected before making the equipment live. In the case of the supply from an isolating transformer, failure to do this will mean that there may be a hazardous shock risk, if there is a simultaneous contact between the enclosure of the equipment and one or both poles of the isolated test supply;
- The integrity of the circuit protective conductor (earth) of all portable/ transportable Class I equipment must be re-tested after all test-bench work has been completed, to make sure there are no earth faults before the equipment is used again on a normal mains supply.

Setting up safe test areas

By setting up a controlled test area, you can ensure that anyone not involved with electrical testing is kept free from risk. This can be done by setting up a controlled test area such as:

- A designated room built as a test area with special protection features and fitted with secure doors (possibly interlocked, depending on the degree of risk) to prevent unauthorized access;
- An area set aside in a workshop with some form of permanent barrier as a boundary to prevent unauthorized access;
- A workbench which might be designed as a test bench or be used for repairs and testing;
- A designated work position in, or at the end of, a production line;
- A temporary area set up around equipment using purpose-built barriers as demarcation;
- An area around fixed equipment, such as switchgear, or control gear, where skilled people are carrying out repairs, faultfinding or testing during maintenance work.

In workshops where all employees have been adequately trained and instructed in safety practices and all unauthorized personnel are effectively excluded, local demarcation of the workbench or work area where testing is done may not be needed. Make sure all employees are aware that others who are not involved in the test in progress should not distract those carrying out testing.

Protecting the people doing the testing

You must put effective measures in place to protect the people doing the testing, to prevent them coming into accidental contact with dangerous exposed conductors. This might be either a single-hand contact with a source of energy which has one of its supply conductors connected to earth, or another area of conducting surface.

Class I equipment is in this category because the mains at source are earth referenced; so is electronic equipment where a large metal surface (or chassis) is connected to the source. There is also a risk of injury from sources of supply which are not earth referenced and where accidental simultaneous contact with both poles of the supply is possible.

Methods of reducing the risk of a shock from simultaneous contact with conductors include:

- Testing at reduced, non-hazardous voltages and currents;
- Using interlocked test enclosures in which the unit under test is contained;
- Using temporary insulation;
- Replacing covers which need not be removed for the purposes of the test, e.g. once supply connections have been made;
- Creating an area which is as earth free as practicable;
- Using isolating transformers connected to the mains supply;
- Using 30mARCDs.

The following sections provide more detail about each of these protective measures.

Safe voltages and currents

It may be possible to test the equipment by energizing it with non-hazardous voltages and current levels. Always consider this as the first option before deciding to use dangerous voltages and current levels.

Interlocked enclosures

These can vary in size from a small bench-mounted box with an interlocked hinged lid to a large enclosure (large enough for people to enter) equipped with access gates which are secured by interlocks. It is important to make sure that the safety performance of the interlocking system is comparable with that of a switching device used for isolation purposes. The use of a trapped key (key exchange).

System interlocked with the access and the isolator can help. In general, interlocking using the control system alone is not acceptable; the power supply should be isolated by the interlock system.

In certain circumstances there may be the potential for a stored charge to occur, e.g. from the use of capacitors. In these circumstances, the supply to the equipment under test should be earthed, preferably automatically, before entry is made. If it is not possible to earth the equipment automatically, it should be manually earthed by the use of a suitably insulated earthing tool. Where automatic earthing is used, it is essential to also use a manual earthing device before making contact with any parts that have previously been made live. Where large enclosures are used, you must make sure people cannot be inside the enclosure while there is danger from the equipment being tested.

Temporary insulation

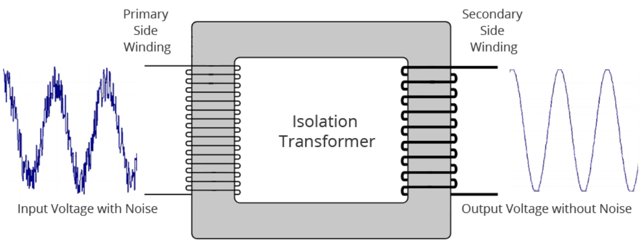
Where there is risk from simultaneous contact with hazardous conductors, do not assume employees will be able to avoid accidental contact. Consider using temporary insulation which may be in the form of purpose-made screens or insulating sheets or shrouding (rigid or flexible). However, there may be a practical limit on using screens when testing compact electronic assemblies.

Earth-free areas

It is difficult to achieve a true earth-free area, as you need to make sure floors and walls will not conduct current which can cause shock injury. So, suitable insulating materials, including mats, are needed to construct an earth-free area. These parts will then have to be tested at regular intervals to demonstrate that their insulation properties are being maintained.

An area, which is as earth free as practicable, can be more easily created, but you need to carry out a thorough risk assessment to ensure that the testers will not make accidental contact with any earthed conductors. Enclose items such as heating and water pipes and radiators, or situate the test area to prevent simultaneous contact by the tester with the item under test and the earthed item. Earth-free areas should have the minimum of exposure of conductive parts. A 30mA RCD could be used as supplementary protection. Earth-free areas are often used in conjunction with isolating transformers. Where it is not possible to make an area earth free because the test equipment and/or the equipment under test needs to be earthed, it is still possible to reduce the extent of the accessible earthed metalwork.

Isolating transformers



Isolating transformers connected in the test supply will prevent the risk of electric shock if a person touches a single live conductor of the isolated supply while in contact with an earthed conductor.

It should be clearly understood, however, that an isolating transformer cannot prevent an electric shock if someone makes contact simultaneously with both conductors of the supply on the secondary side of the transformer, unless the output voltage is below 50Vac (120Vdc) in dry conditions and 16Vac (35Vdc) in wet conditions.

Test the integrity of the isolation from earth regularly, or install earth fault monitoring devices, to ensure that dangerous earth faults are detected.

Residual current devices (RCDs)

These are supplementary protection devices, which do not prevent an electric shock, but are able to limit the duration of some shocks by being able to cause rapid dis connection of the electricity supply if there is a relatively low current flowing to earth, such as may occur during an electric shock. They are, therefore, able to provide a much higher level of protection against the risk of a severe electric shock than could be provided from an unprotected source.

An RCD required to minimize the risk of personal injury should have a rated tripping current of no more than 30mA and should not have an adjustable time delay.

Although the 30mA versions are often used, those with lower rated tripping currents (typically, 10mA or below) are readily available and may be used to provide additional protection where nuisance tripping is not a problem.

Where personal safety depends in part on the operation of an RCD, the RCD must be tested using the built-in test facility at appropriate intervals (e.g. portable RCDs before each use, fixed RCDs weekly). In addition, all RCDs should be tested at least annually using an RCD tester, which will check the tripping current and the speed of operation.

Test equipment

Where possible, test equipment should be of a proprietary design. In this case, the manufacturer should have taken account of its safety performance during use. Where applicable, test equipment should be manufactured to the required standard and quality.

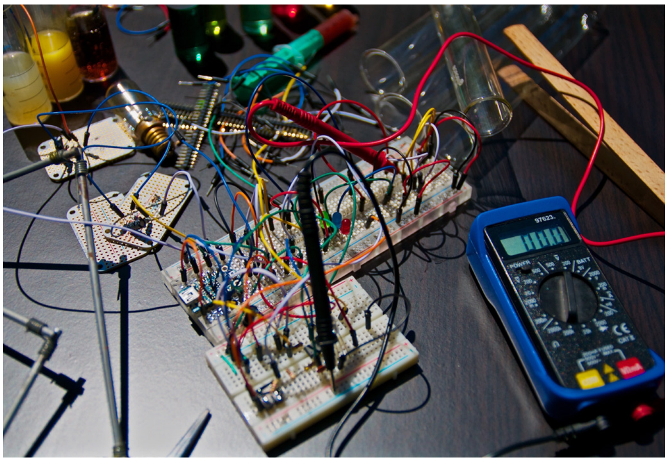
Purpose-built test equipment must be designed and constructed to the same standards of safety as proprietary equipment. Where equipment is mains powered. It must be safe to use as a piece of electrical equipment in its own right. In addition, the arrangements for connecting it to the equipment under test must be safe.

Insulation test instruments can generate high voltages at their output and some have an option to limit the output current to a safe level. Since 2001, test equipment has the output current limited to 3mA, older test equipment may be limited to 5mA.If accidental contact with the output conductors occurs, the risk of injury will be minimized if these current levels are not exceeded.

If higher current levels are necessary, put special precautions in place to prevent injury. These include using test probes fitted with control switches, or using interlocked enclosures to prevent access to the dangerous parts, and restricting the testing work to authorized people. Most insulation testing can be done within the safe current limits specified above.

The connecting leads of test equipment must be of a design that provides adequate protection from electric shock. The only exception to this is when test lead connections are inside an interlocked enclosure and are connected to and disconnected from the equipment under test, while the source of supply is isolated and measures are taken to ensure that any stored energy is dissipated. In this case, the connecting lead conductors become an extension of the conductors being tested and so present the same risk of injury.

Test instruments



This section applies mainly to oscilloscopes but can sometimes apply to other instruments, e.g. signal generators.

Hazardous voltages may arise on the enclosures of Class I (earthed) oscilloscopes, or, in some cases, on certainty pes of double-insulated, Class II oscilloscopes. The hazardous voltages may arise from the voltages being measured on the equipment under test, or in some cases, from the breakdown of the insulation of the oscilloscope itself. The measurement problems arise because most oscilloscopes have the 'signal common' terminals connected to the oscilloscope's chassis and so its enclosure and connectors. In a Class I oscilloscope these parts are connected to the supply protective conductor. This means that all measurements must be made to earth, which limits the measurements that can be made by the oscilloscope.

A technique has been developed to 'float' the oscilloscope (i.e. remove the connection to the supply protective conductor) which then allows the oscilloscope's enclosure to float above earth potential (which could beat high voltages for some types of measurement) with obvious possible shock risks. Operation of an oscilloscope with the protective conductor removed means that it is no longer protected against internal insulation breakdown. Another disadvantage with this situation is that it will then be necessary to attempt to create an earth-free area. Such use also defeats the equipment manufacturer's primary protection concept for Class I protection and should be discouraged.

A number of methods have been developed to allow floating measurements to be made more safely. One method is to supply the oscilloscope via an isolation transformer's ore moving the earth reference in the supply and allowing floating measurements. The advantage of this method is that an earth-free area is not required but the disadvantage is that the oscilloscope is not protected against internal insulation breakdown to the chassis. (The oscilloscope's internal insulation could be over-stressed if high-voltage measurements are being taken.)

A second method is to use a proprietary isolation monitor (sometimes called a line isolation monitor or an earth (ground) isolation monitor) in the supply to the oscilloscope. This allows the oscilloscope to operate with its protective conductor disconnected but the monitor continuously checks the voltage between the oscilloscope's enclosure and the supply earth. If the oscilloscope's enclosure reaches a hazardous voltage, the monitor removes the mains supply to the oscilloscope and usually reconnects the supply protective conductor. A typical operational setting for a monitor would be about 30VRMS. The oscilloscope would still be protected against internal insulation breakdown.

The disadvantage is that it can only be used to measure low-level signals because the oscilloscope's internal insulation could otherwise be over-stressed.

In recent years, developments have led to various devices that can be used in an oscilloscope's measuring probes which allow the Class I oscilloscope to be earthed to the mains supply, but which isolate the measured voltages to prevent them appearing on the oscilloscope's enclosure. Modern proprietary devices use various techniques to achieve isolation (e.g. opto-isolators) and typically allow measurements to be made ranging from millivolts to thousands of volts. Bearing in mind the risks involved, such isolators should be regarded as being reasonably practicable safeguards.

The isolation devices come in several forms and may have slightly different names, according to the manufacturer. Some of the common names for these devices are: isolate on amplifiers; differential amplifiers; and isolation probes. Corrects election of device, according to the measurements to be made, is important. The user should seek the manufacturer's advice.

Some manufacturers now offer oscilloscopes with isolated inputs (i.e. where the measured inputs are isolated from each other and from the oscilloscope's chassis), up to reasonably high voltage levels (typically 850Vpeak ac and dc). Consider using these as well as all-insulated, Class II oscilloscopes. Battery-operated oscilloscopes, which can be used up to, reasonably high-voltage measurement levels are available. These are not referenced to earth.

It is good practice to include an RCD with a rated tripping current of, at most, 30 mA in the power supplies to Class I instruments, soldering irons and any other mains-powered equipment. If isolation transformers are used to supply power to fixed socket outlets as part of a distribution system for test supplies, the sockets should be of a different type to standard sockets, or of the polarized type, to make sure they are only used for the purpose intended.

Safe systems of work

Details of safe systems of work for testing activities should, wherever it is reasonably practicable to do so, be documented. To produce a workable system, all personnel should be involved in preparing the safe systems of work. The completed documents, which will need to be reviewed from time to time, should be made readily available to employees.

Where testing is confined to diagnostic testing on electrical distribution systems and equipment (e.g. switch gear), by electrically competent persons, the contents of the written documents should cover the essential safe working practices. They may not need to cover the inherent background knowledge of such a competent person (this will of course depend on the experience of the competent person).
Test personnel employees who work in customers' premises might have to work under different rules, as compared to working at a factory-based test facility. This means that there may be need to have two sets of rules. Consider this when producing the safe system of work.

The contents of the written safe systems of work should include, as a minimum, details of:

- Who is authorized to undertake testing and, where appropriate, how to access a test area and who should not enter the area;
- Where temporary test areas are constructed, how this is to be done;
- Rules for isolating equipment and how the isolation is secured;
- The correct use of additional protection measures, e.g. flexible insulation that have to be applied to the equipment under test while its covers are removed. If it is considered necessary to apply the insulation and remove covers while the equipment is live, this risk should also be assessed;
- What form of power supply to use to energize the equipment under test, particularly where using the wrong method would compromise safety;
- What is expected of test personnel regarding the inspection of test equipment before use, and how to report defects;
- The correct use of any warning devices that form part of the safety system at designated test areas;
- Instructions about what action to take in an emergency situation;
- Procedures to follow when a contractor undertakes the testing (see 'Competence of testers').

Training all personnel involved in testing should be given specific safety training relevant to the work they are doing. Appropriate training or instruction must also be given to anyone who may attempt to enter test areas and approach test benches.

You are likely to need to provide new training whenever any of the following changes take place:

- Product design, layout and installation;
- Production or working methods;
- Test methods and instruments;
- Test personnel and others who may be affected.

Competence of testers

Ensure people working on electrical equipment or systems are 'competent' for the task. Being competent means having suitable training, skill, and knowledge for the task to prevent injury to yourself and others. In small businesses, skilled electricians or technicians are sometimes employed to look after the day-to-day operation of the electrical systems. If such people are involved in setting up testing arrangements, make sure that they are aware of all aspects of safety relating to testing. Specialist competent advice may be needed to make sure that the testing procedure is safe.

When setting up a testing area, it is important that every one, and in particular those who are electrically unskilled or inexperienced, are protected from electrical danger at all times. Appropriate precautions will also need to be taken to prevent people who have electrical knowledge and skills being injured. Remember that even a skilled person can make accidental contact with dangerous electrical conductors if they are not protected. Do not rely on someone's personal electrical competence as their main protective measure.

Review precautions regularly, as part of your risk assessment process to make sure they are being followed and are still appropriate for the work being done. As part of this safety review, give employees sufficient instruction and training on how the safe working procedures have been amended. This is especially important where there is a change in the design of the products being tested, which is relevant to how the protection concepts are applied.

Designs should be reviewed and any necessary changes to safety procedures implemented after discussions with the test personnel. A safety review must be carried out when changes are made that may affect testing work, such as changes in production methods, supply arrangements, test methods and instruments, or when personnel changes are made.

Where a contractor does testing, safe working, arrangements must be discussed and agreed before the work starts, preferably at the contract discussion stage. This enables everyone concerned to know who is doing what and who is responsible for what, so the work can be done safely and without risk to the contractor's employees, the site employees and others who might be affected. In particular, the person who is responsible for the safe isolation and state of the equipment should be identified and agreed.

6.2 MANAGING HAZARDS AND WASTE

Introduction

Maitenance can be defined as process done to keep items to have a longer life span.

Types of maintenance

There are two major types of maitenance, namely:

i. Preventive maintenance- service maintenance
ii. Corrective maintenance –breakdown maintenance

In the workshop, a maintenance department does many different types of work which are inter-dependent and must tehrefore be coordianted. The following types of workk are associated with workshop maintenance

i. Administration
ii. Preventive maintenance
iii. Corrective maintenance
iv. Modification
v. Replacement

Administration:

The functions of maintenance administration consits in designing and putting into effect the various systems of the maitenance organization. The following systems are frequently employed in maintenance departments

a. Machinery records
b. Spare parts system
c. Preventive maintenance system
d. ork sequence system

Maintenace adminstration also entails the purchasing of spare parts, consumable items and services.

i. Preventive maintenance:

This type of maitenance includes all types of programmed maintenance or all measure aiming at at the prevention of faults or at the discovery of incipient faults before any serious demag can take place

ii. Corrective maintenance:

Even with a well- developed preventive maintenace system, there is always need for corrective action. The term " Corrective maintenance" relates to any work with the purpose of correcting faults.

iii. Modification:

In many cases modifications have to be carried out in order to adept the production equipment to current requirements.

iv. Replacement:

For any workshop to remain efficient, equipment will have to be replaced from time to time. This is another area in which the maintenance department normally carries out such work as is necessary.

Preventive maitenance means an ction is taken before a fault occurs. Preventive maintenance can be divided into two parts

i. Direct preventive maintenance-doing something like replacning, oiling machines, planned replacement and renewal. Direct maitenance is often carried out after a certain number of operating hours or calender months.
ii. Indirect preventive maintenace- knowledge, condition monitoring. Cover all operations intended to determine the need for direct preventive maintenance measures of repairs

Corrective maintenance

Also known as replacement maintenance, describes measures, teh purpose of which is to correct faults ie to restore damaged equipement to its proper functional state. Corrective maintenance is often refered to as ' repair work.'

Importance of maitenance

Preventive maitenance yields numerous benefits including

i. Minimum maintenace cost
ii. Maitenance performed when convenient
iii. Ability to constract maintenance
iv. Less downtime- If the job can be done before removal of the equipment from service, the time that the equipment is out of service can be minimized
v. Minimum spare parts inventory
vi. Less disruption through emergency maitenance
vii. Less standby equipment needed
viii. Less overtime needed
ix. increased safety
x. Less polution

Planning of maintenance

Planning means – activities /process doen to achieve goals. Paper planning makes it easier to ensure that eadh operation is carried out at teh right time. It is also necessary to plan for availability of spare parts, tools etc. Through planning maitenance cycle can be designed to ensure that the organisation, the systems and the wroking methods are efficient. The figure below illustrates the cycle according to which all maintenance should be carried out.

Every maintenance cycle leads to new experience, which may have to be taken into account at the planning stage. If this is done, maitenance can be directed towards the general aim "to ensure adequate operational realaibility and personal safety at minimum expenditure

Fault identification

Frequent workshop inspection can detect different types of faults in a sewing machine. There are basically two types of faults in machiens

i. Random faults
ii. Regular faults

Random faults

These are faults which occur in an irregular manner as to make theri prediction impossible. A randow fault may, far instance, be due to an un fore seen overload. These are two types of random faults

a. Observable random faults

b. Non observable random faults
c. Observable random faults

These take a certain time to develop, such faults can be discovered by inspection

Non- observable random faults

Such faults do not develop over a period of time, and it is therefore impossible to detect them by inspection. Only one thing can be done to prevent such faults from occuring again in future, they must be recorde and their causes, must subsequently be analysed with a view to improving the design or mounting of the machine concened. Non-observable radom faults may be due to faulty materials, faulty control etc.

Regular faults

This type of faults develop in stages in accordance with known and or recordable sequence. They may be due to wear and tear, chnages in material due to desication, crystallisation and other causes. Regular faults can also be subdivided into observable and non observable faults.

Scheduled preventive maitenance

A thorough preventive maitenance program identifies all points in facilities, machinery equipment that require maintenance attention. It shows appropriate periodic inspection time, what needs adjusting and tightening , cleaning, lubricating and renewal through routine parts replacement. In most systems, this goal is met through maintenance checklists and route sheets. A maintenance checklist is like a guide tour of a piece fo equipment. Systematically it leads the maintenance through the important points of the machine, giving instructions on how to spot trouble or potential failures and then telling what to do when a problemis found.

6.3 BASIC INSTALLATION & ASSEMBLY

Battery Banks

DC systems on site include banks of batteries, motor-generator (MG) sets or battery chargers, and the necessary system wiring and controls to supply the DC power. The function of a DC electrical system is to provide power to essential control systems and equipment, which does not depend on normal AC power.

For safety, it is required that battery rooms have an eyewash station, in case acid from the batteries is sprayed in the face of the operator. Ventilation fans should always be operating to prevent hydrogen gas buildup. Due to the possibility of hydrogen gas being present there will be NO SMOKING in the battery rooms and always make sure the ventilation fans are operating before entering. Only qualified personnel should enter a battery room. Only necessary tools should be taken into the battery room. All tools should be insulated tools. Rubber blankets should be utilized any time when working overhead. This reduces the likelihood of shorting out the DC system. Batteries should be covered with suitable insulating materials (i.e., rubber blankets) when personnel are working overhead with tools or metallic objects. Shorting the DC system is extremely dangerous because the system may not be protected by an over current device.

Battery Chargers

There are numerous styles of battery-operated trucks that range from small, motorized pallet trucks to much larger high lift trucks. No matter what kind of truck you have, there are similar hazards associated with their batteries and their chargers. There are two styles of batteries in industrial trucks today: Lead acid or nickel-iron. Both of these batteries pose a health threat in several ways:

- Gases emitted during changing can be highly volatile
- Corrosive chemicals within the battery

For these reasons, battery charging stations and the employees that work around them must be properly equipped and certain safety procedures implemented. The following procedures must be followed:

1. Eye or face protection must be worn when connecting a charger to a battery.
2. Chargers must be turned off when leads are being connected or disconnected.
3. All leads and cables must be checked and in good condition.
4. When charging batteries and when moving batteries, vent caps must be kept firmly in place to avoid electrolyte splashing
5. If charging is to be conducted on a battery in a mobile piece of equipment, the battery compartment cover must be left open to vent heat and explosive gases.
6. There must be adequate ventilation in the charging area.
7. The battery charger must be protected from damage. This usually means a physically protected area.
8. Facilities for quick drenching or flushing of the eyes and body must be provided at or near the charging area (approved emergency eyewash and safety shower).
9. Smoking must be prohibited in the charging area. "No Smoking"

Electrical Power Tool Safety

- Use the tool ONLY for its designed purpose.
- Read the Owner's Manual and follow manufacturer's safety instructions.
- Remember electric-powered tools must have a three-wire plug with ground or be double insulated.
- Use of electric-powered tools with GFCI breakers will drastically reduce the possibility of electric shock or electrocution.
- Don appropriate PPE.
- If an extension cord is required, make sure it is for the correct wattage and has the proper plugs.
- Verify condition of the cord and plugs and check for rated use: indoor or outdoor.
- Ensure the power switch is "OFF" before plugging or unplugging tools.
- Never disconnect power by pulling on the cord – use the PLUG.
- Never carry a tool by the cord.
- Unplug the cord before making adjustments, changing/replacing parts/accessories.
- Inspect tool before each use. Replace tool if parts are worn or damaged as seen if Figure 30.
- Remove from service and tag "Danger, Do Not Operate.

REPAIR OF SOLAR PANEL

Solar PV System

Solar PV (photovoltaic) systems convert the light energy from the sun in to household usable electricity. The energy is generated on-site without emitting greenhouse gases and is generated from a free, renewable energy source.

Benefits of solar energy:

- Solar electricity is generated without emitting greenhouse gases
- Solar electricity is generated on-site from a free renewable energy source
- Buffer against future increases in energy costs
- Solar modules should last 20 to 30years
- Solar electricity helps stabilize the power grid and provides more electricity during peak power
- Unobtrusive and silent
- Increase the value of your home/business.

What to consider when purchasing a Solar PV system:

Factors to consider in addition to price include:

- Level of company experience and previous customer satisfaction with service provided
- Warranty on inverter and panels, including product and performance warranties
- Size of system and capability for inverter upgrade in future
- Expected daily yield in kilowatt hours (kWh)/units
- Your current and future energy demands
- Available roof area, orientation and any current or future issues with shading (i.e. trees, possibility of development on neighbouring properties)

Type of panels and Orientation

Panels should ideally be installed on a north-facing roof, at an angle determined to maximize solar radiation at that particular site location. The area should receive direct sun with no shading between the hours of 9am-3pm

There are three main types of solar panels:

Monocrystalline

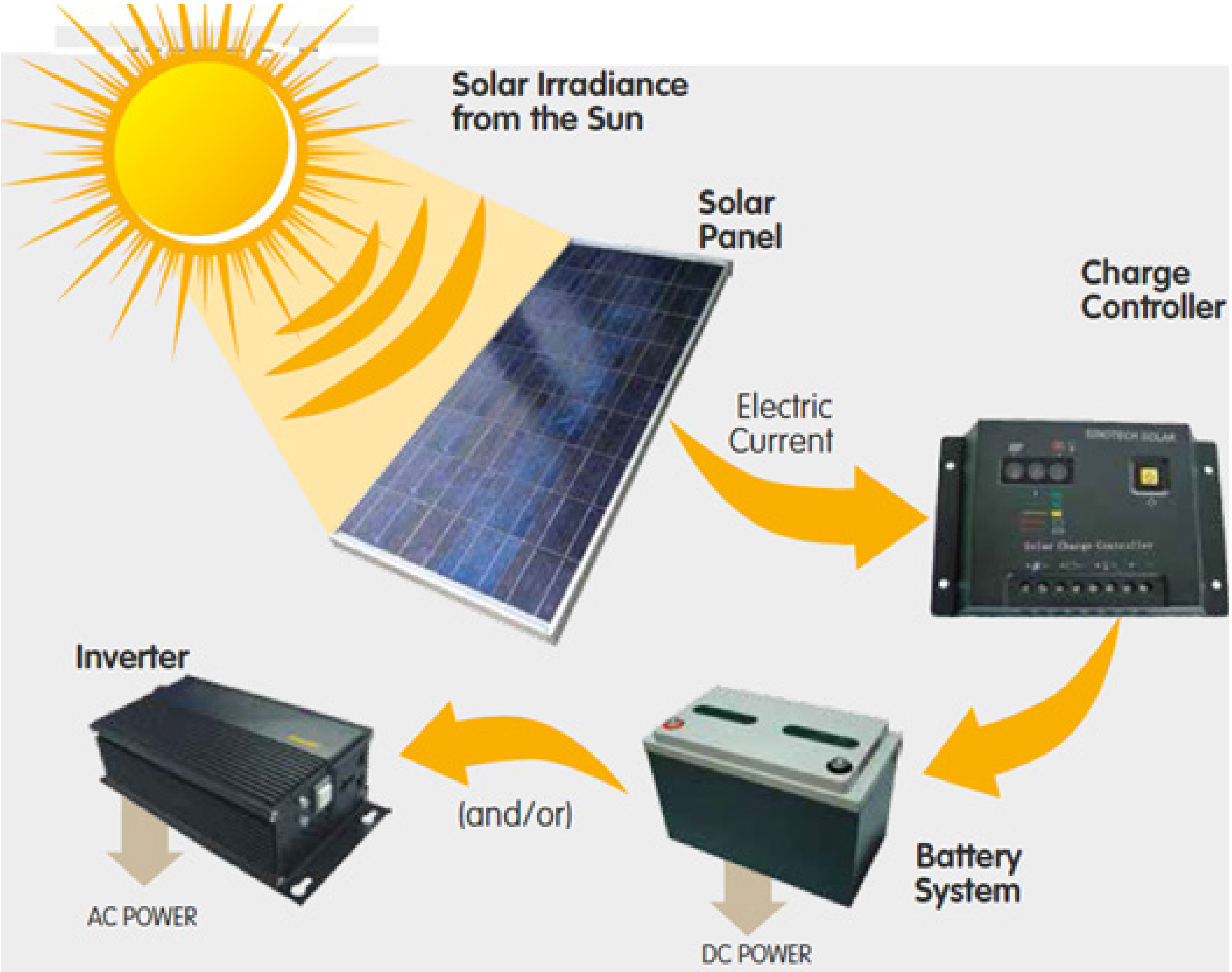
- Proven technology that has been in use for over 50 years
- Highest efficiency of 12-15%, therefore is used where space is limited, or where there are high costs associated with installing large or many panels
- Very slow degradation, generally 0.25- 0.5% efficiency reduction per year.

Polycrystalline

- Similar to monocrystalline panels, but the silicon used is multi-crystalline which is easier to make
- Comparable to monocrystalline in performance and durability, except their efficiency is slightly lower, generally 11-13%
- Slightly more panels are required than monocrystalline to produce the equivalent amount of electricity.

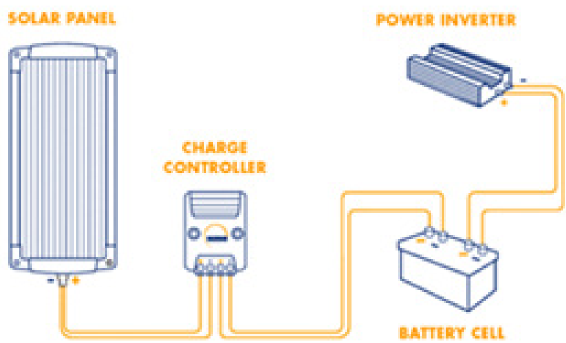
Amorphous thin film

- Lower efficiency of 5-6%, therefore panel is nearly double the size of other panel varieties to produce the equivalent amount of electricity
- Respond well to slightly diffuse (reflected) light
- Experience a reduced loss of efficiency at higher temperatures, in comparison to other panel types.



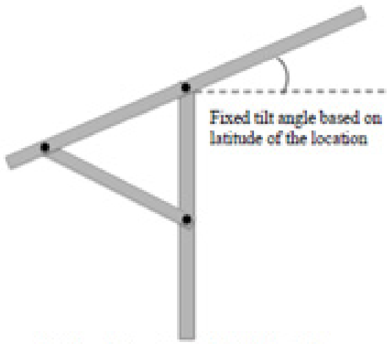
Adopted from Pachanri, R.K (2008) from Sunlight to Electricity practical guide, page 34-40

A complete solar system consists of a solar panel, a battery and a charge controller. In some cases, a power inverter is also required.

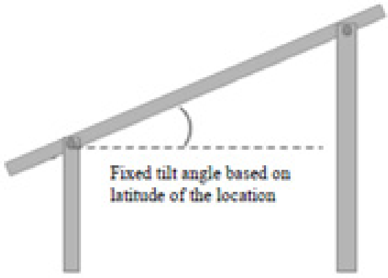


- Composed of multiple solar cells in series or in parallel, a solar panel produces direct current (DC) power; when a solar panel is connected to a battery, this power is stored in the battery.
- A charge controller connected between the solar panel and the battery monitors the battery and prevents the solar panel from overcharging the battery while assuring a complete charge.
- Clouds affect solar panels. The amount of power your solar panels can produce is directly dependent on the level of light they receive. In full, bright sunlight, solar panels receive maximum levels of light. During those "peak" sunlight hours, your solar panels will produce power at their maximum capacity.

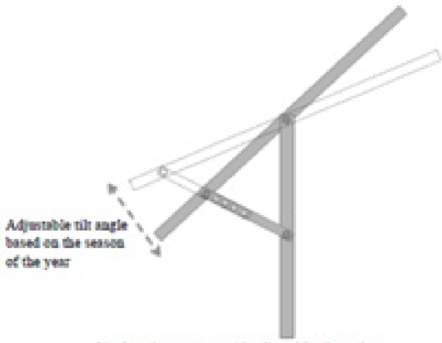
- When clouds cover the sun, light levels are reduced. This does not shut down power production, however. If there is enough light to cast a shadow, in spite of the clouds, your solar panels should operate at about half of their full capacity. Thicker cloud cover will reduce operations further. Eventually, with heavy cloud cover, solar panels will produce very little useful power.



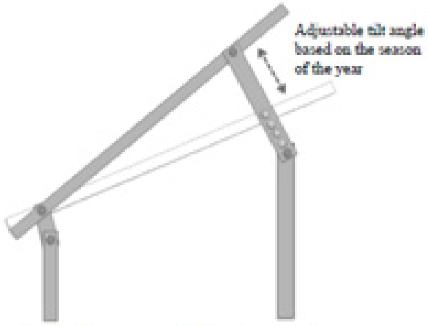
Single pole structure with fixed tilt angle



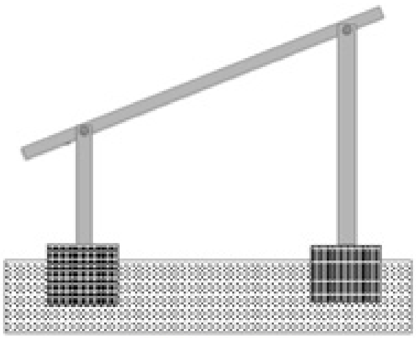
Double pole structure with fixed tilt angle

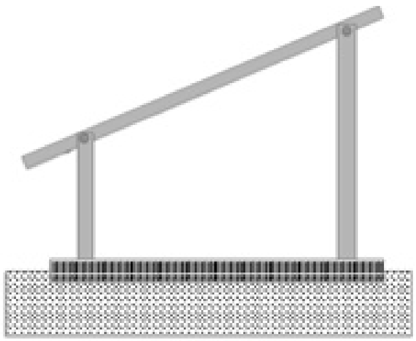


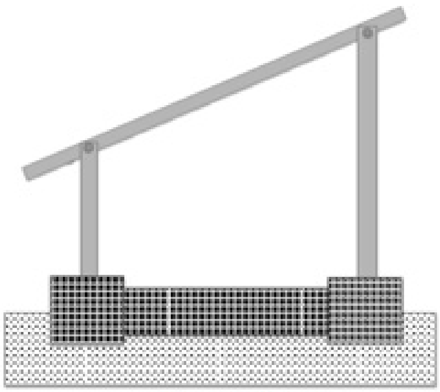
Single pole structure with adjustable tilt angle

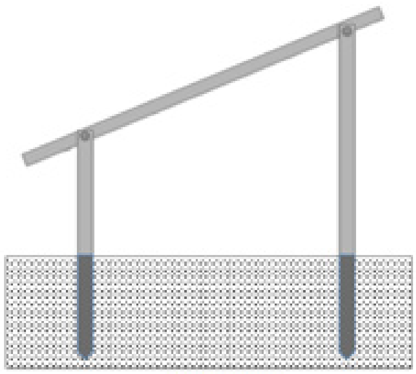


Double pole structure with adjustable tilt angle


Block type foundation


Slab type foundation


Beam type foundation

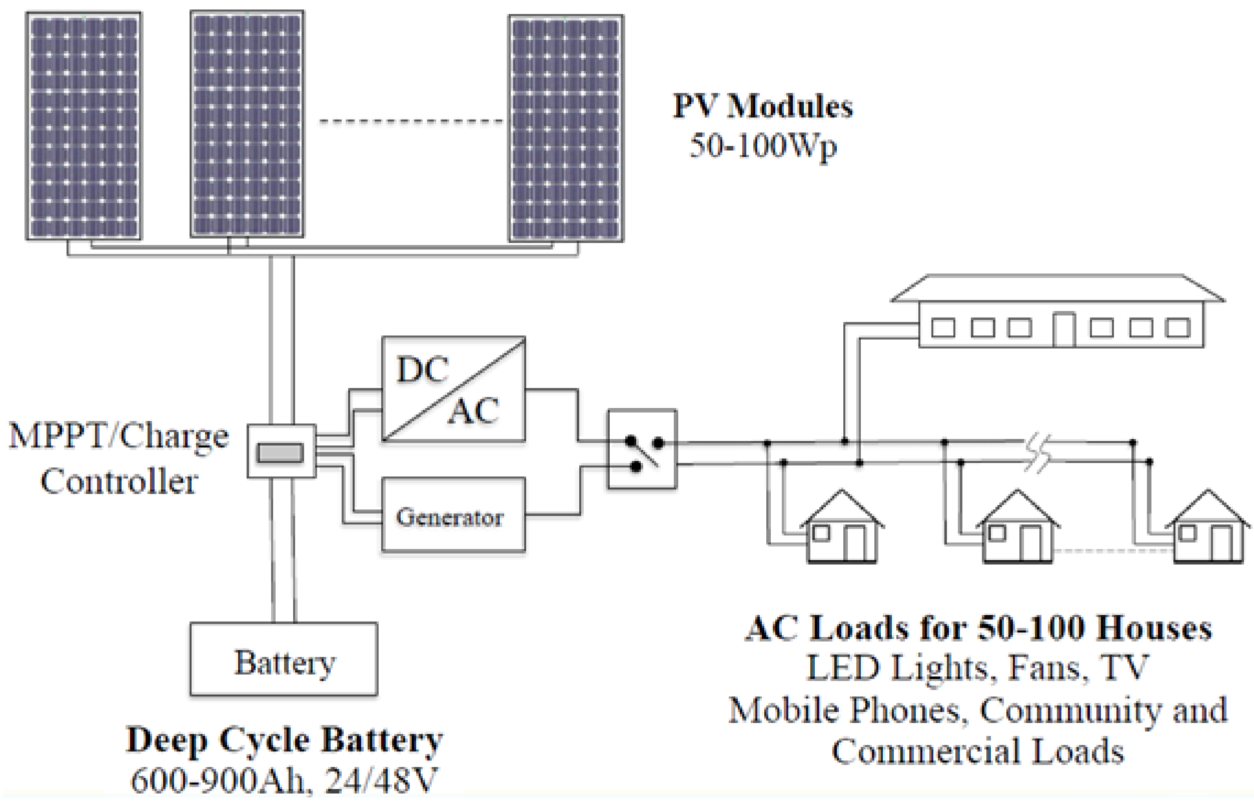

Pile foundation

Foundation for array mounting structure may be different for different sites, types and load bearing capacity of soil, windy velocity, waterlogging possibility and type of mounting structure. Conceptual drawing of foundation type generally used to hold array structure are shown above.

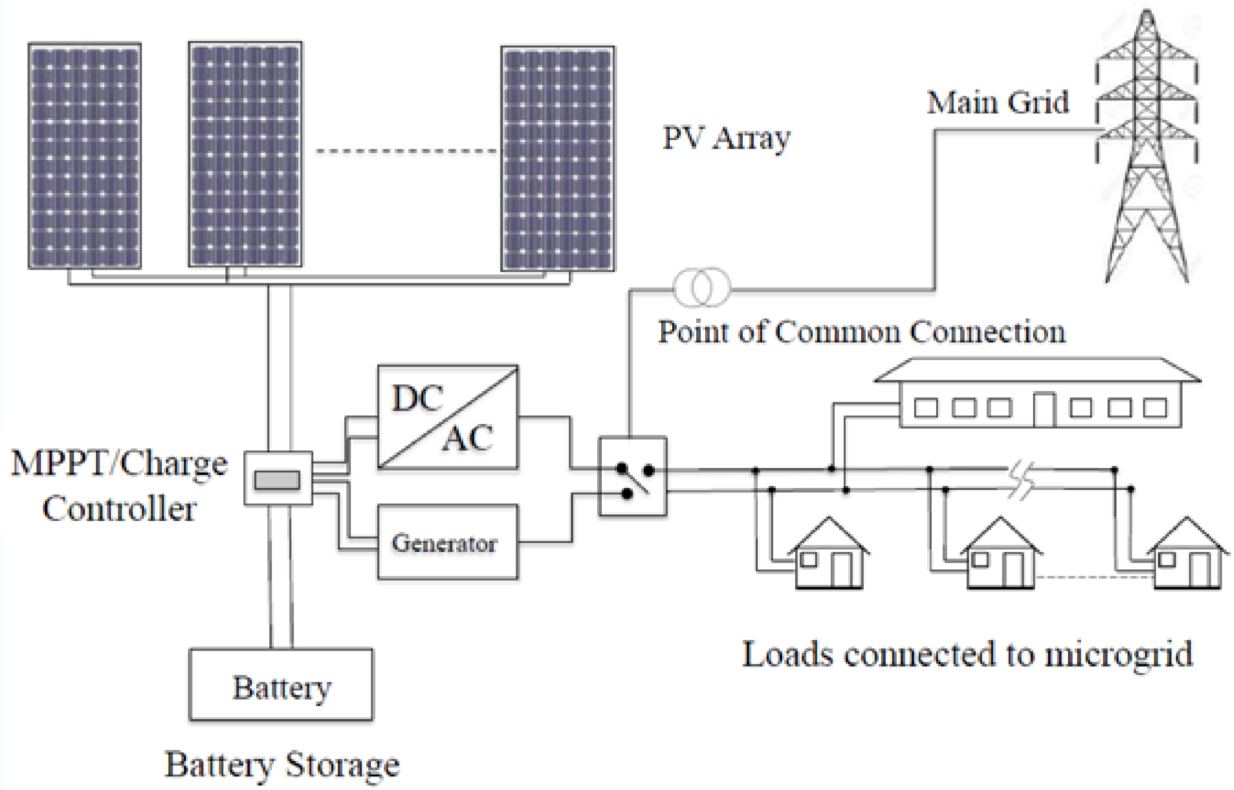
array installed on a roof of the control room

beam type foundation

PV-DG Hybrid Microgrid System



Microgrid System connected to main grid



(Source: Kolhe, M (2015) Wiring Regulations 17th Edition, page 70-73)

A solar system requires an inverter when the DC power needs to be converted into alternating current (AC) power to operate appliances or supply power to the utility grid.

Sample revision questions:

1. State the factors that determines system configuration for solar micro grid system
2. List the types of solar micro grid system
3. Explain the benefits of connecting micro grid system to the main grid
4. What are the criteria for designing a solar micro grid system?
5. List parameters for designing solar micro grid system
6. List considerations to be taken on cables

Photovoltaic System Types

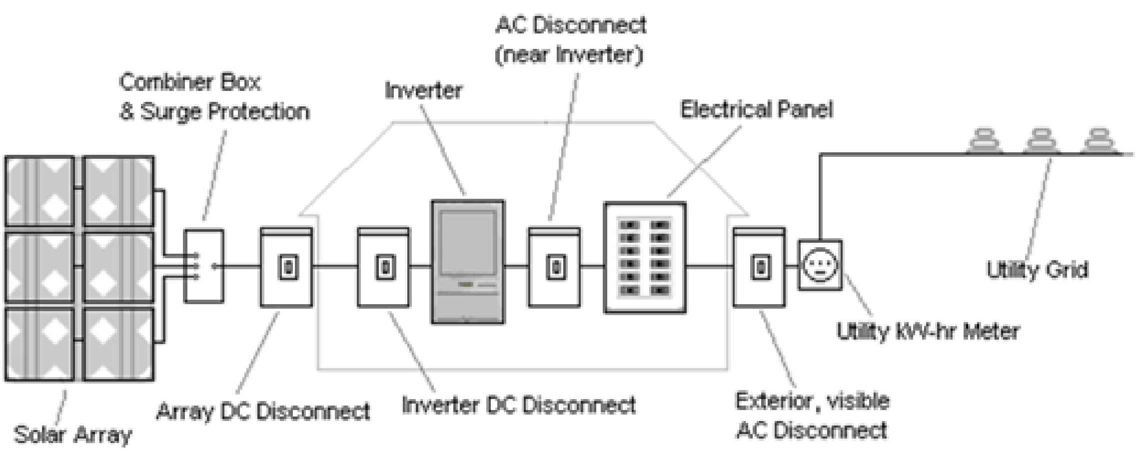
Photovoltaic system types can be broadly classified as:

- Grid-connected AC system with no battery or generator back-up.
- Grid-connected AC system with battery backup.

The simplest, most reliable, and least expensive configuration does not have battery backup. Without batteries, a grid-connected PV system will shut down when a utility power outage occurs. Battery backup maintains power to some or all of the electric equipment, such as lighting, refrigeration, or fans, even when a utility power outage occurs. A grid-connected system may also have generator backup if the facility cannot tolerate power outages. With battery backup, power outages may not even be noticed. However, adding batteries to a system comes with several disadvantages that must be weighed against the advantage of power backup.

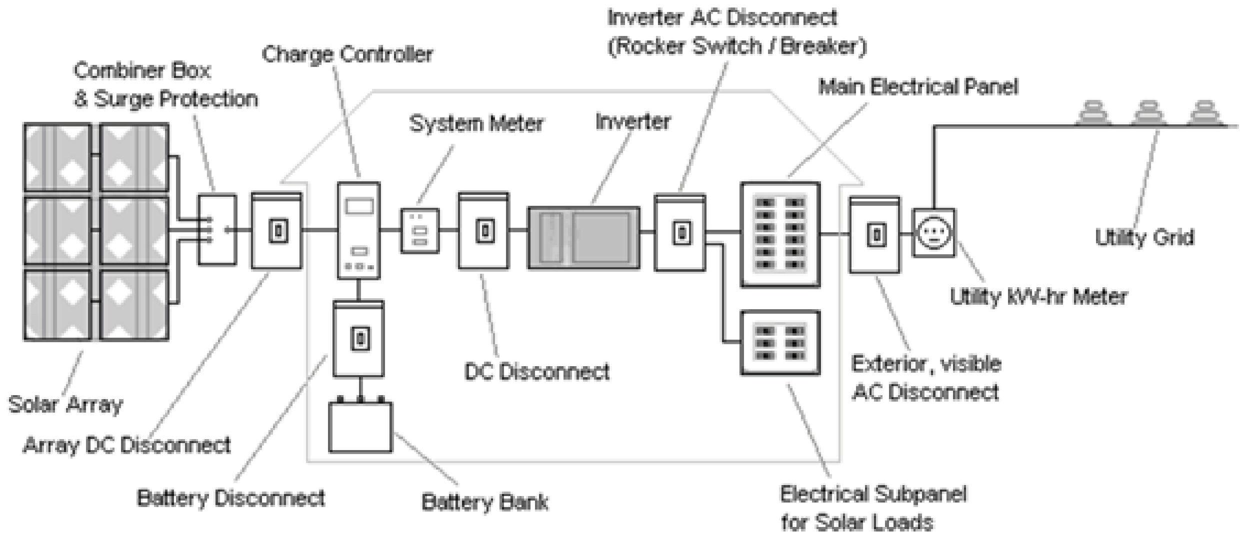
These disadvantages are:

- Batteries consume energy during charging and discharging, reducing the efficiency and output of the PV system by about10 percent for lead-acid batteries.
- Batteries increase the complexity of the system. Both first cost and installation costs are increased.
- Most lower cost batteries require maintenance.
- Batteries will usually need to be replaced before other parts of the system and at considerable expense.



grid-connected AC photovoltaic system without battery back-up

(Source: Kolhe, M (2015) Wiring Regulations 17th Edition, page 75-76)



grid-connected AC photovoltaic system with battery back-up

(Source: Kolhe, M (2015) Wiring Regulations 17th Edition, page 77)

System Components

Pre-engineered photovoltaic systems can be purchased that come with all the components you will need, right down to the nuts and bolts. Any good dealer can size and specify systems for you, given a description of your site and needs. Nevertheless, familiarity with system components, the different types that are available, and criteria for making a selection is important.

Basic components of grid-connected PV systems with and without batteries are:

- Solar photovoltaic modules
- Array mounting racks
- Grounding equipment
- Combiner box
- Surge protection (often part of the combiner box)
- Inverter
- Meters – system meter and kilowatt-hour meter
- Disconnects:
  - Array DC disconnect
  - Inverter DC disconnect
  - Inverter AC disconnect
  - Exterior AC disconnects

If the system includes batteries, it will also require:

- Battery bank with cabling and housing structure
- Charge controller
- Battery disconnects

General Installation Notes

Proper roof mounting can belabor intensive, depending largely on the type of roof and how the mounting brackets are installed and sealed. It is best to follow the recommendations of the roofing contractor, racking system suppliers and module manufacturers. Module manufacturers will provide details of support requirements for their modules. A good racking supplier will provide code-compliant engineering specifications with their product. As a rule for bidding purposes, however, it is typical to have one support bracket for every100 watts of PV modules.

Particular attention must be given to securing the array directly to the structural members of the roof and to weather sealing of roof penetrations. All details regarding attaching the mounting brackets to the roof and sealing around them are best approved and carried out by the roofing contractor so that the roof warranty will not be voided.

Asphalt Composition Roofs

For asphalt composition roofs, all mounts need to be secured to the roof with stainless steel lag bolts, bolted into the rafters. Mount types include support posts and L-brackets. Support posts are preferred because they are designed to give a good seal on boots. Support posts are best mounted after the roof decking is applied and before the roof material is installed. Either the roofing contractor or the crew in charge of laying out the array mounting system may install support posts and roof jacks. The roofing contractor then flashes around the posts as they install the roof.

It is very common to install mounts after thereof is installed, drilling through the asphalt composition roofing to install the bolts. Sealant is then applied around the bolts without flashing. As well, the top layer of roofing should be carefully lifted back to inject sealant under the roofing. While this is much less labor intensive than when flashed, unless performed by the roofing contractor, this method may void the warranty on the roof.

Metal Roofs

There are several types of standing seam metal roof products, including vertical seam, horizontal seam and delta seam products. Currently, special clamps, referred to as S-5 clamps, are available to attach arrays without any penetrations to vertical and horizontal seam roofs and certain other standing seam roof profiles. These clamps make installation of the solar array a relatively easy matter compared to any other roof type. In contrast, clamps for delta seam metal roofs are not available. For these roofs, it is necessary to cut into the roofing, install boots around the mounting posts, and then seal the penetration. This being undesirable and labor intensive, it is best to clearly specify in advance a vertical or horizontal seam metal roof or other roof type compatible with S-5 clamps.

Other Roof Types

While it is possible to install a PV array on shake, tile and slate roofs, these roof types pose certain problems. Contact the racking system supplier for information on products and installation methods for these roof types. Work directly with the roofing contractor before ordering the racking system. Also, look for roof- integrated modules that can be used with tile or slate roofs.

6.4 BASIC OFF-GRID SOLAR PV SYSTEM REPAIRS AND TESTING

Unplug electrical appliances from the power supply before you make any adjustments to that appliance, during or after repairs. You must test any repaired electrical appliance, cord set, or extension lead, before reconnection to the power supply.

If the electrical appliance, cord set, or extension lead is still faulty after you have worked on and tested it take it to a licensed electrical worker to have it repaired.

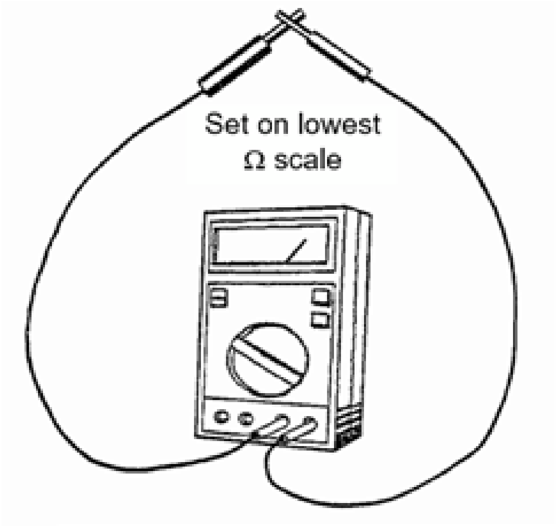
For testing, you must use a multi-meter that measures AC voltage and DC resistance (Ohms (Ω) range). You should have this meter with you before you begin repairs. The minimum resistance range of the multi-meter must be between 0 Ωto 200,000Ω.

Always check the correct operation of the multi-meter before commencing any tests:

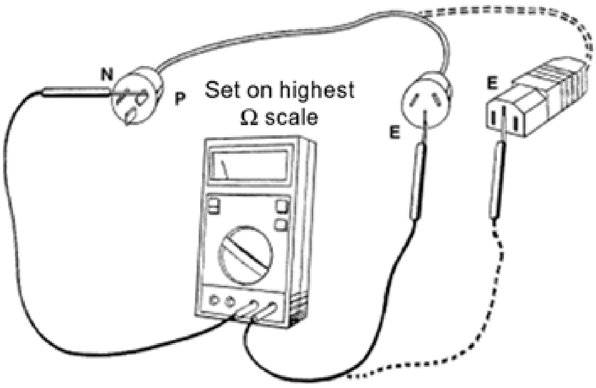
a. The resistance reading is checked by turning the meter to the Ω range and then connecting the meter probes together. The reading should be zero. If the meter can be adjusted, adjust it to read zero. NOTE, digital meters are self-ranging.
b. The voltage reading is checked by turning the meter to the required voltage range (250V AC) and then measuring the voltage at a socket-outlet. Turn the socket-outlet switch to the "OFF" position, push one probe into the neutral (top right looking at the front of the socket-outlet) or into the earth (bottom) slot, and push the other probe into the active (top left) slot. Turn the socket- outlet switch to the "ON" position. The reading at the meter should be in the range of 220V - 240V.

CONTINUITY TESTER

To measure accurately the resistance of the conductors in an electrical installation we must use an instrument which is capable of producing an open circuit voltage of between 4 and 24 V a.c. or d.c, and deliver a short circuit current of not less than 200 mA. The functions of continuity testing and insulation resistance testing are usually combined in one test instrument.



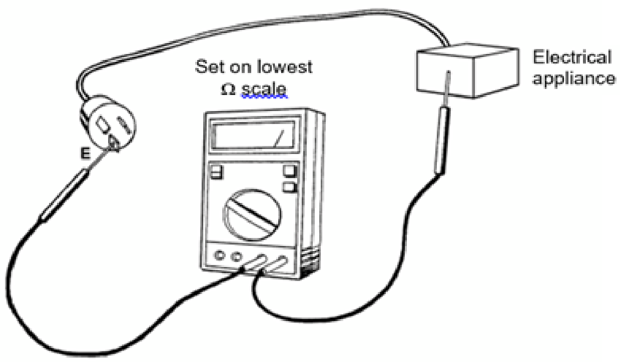
METER CALIBRATION TEST



Active or Neutral and Earth Tests

EARTH FAULT LOOP IMPEDANCE TESTER

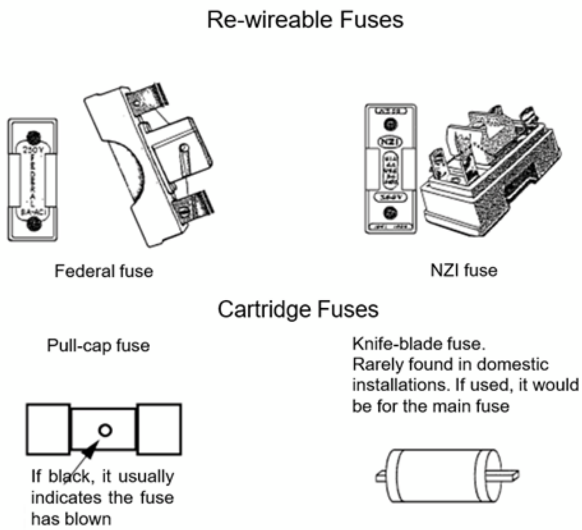
The test instrument must be capable of delivering fault currents as high as 25 A for up to 40 ms using the supply voltage. During the test, the instrument does an Ohm's law calculation and displays the test result as a resistance reading.



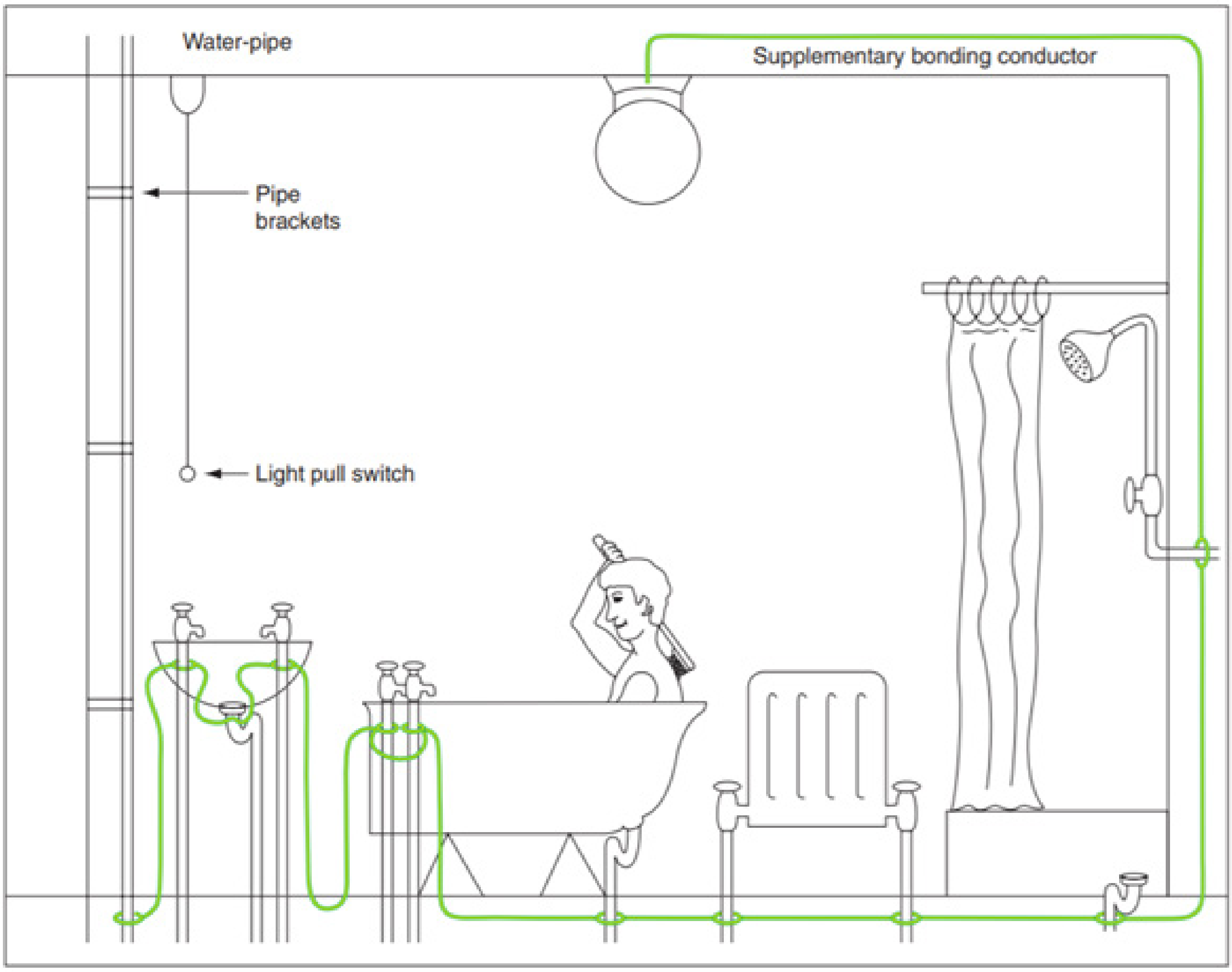
EARTH TEST FOR ELECTRICAL APPLIANCES

INSULATION RESISTANCE TESTER

The test instrument must be capable of detecting insulation leakage between live conductors and between live conductors and earth. To do this and comply with Regulation 612.3 the test instrument must be capable of producing a test voltage of 250 V, 500 V or 1000 V and deliver an output current of not less than 1 mA at its normal voltage.



Adopted from Boxwell, M (2010) Practical guide to solar energy design & installing solar PV



(Source: Kolhe, M (2015) Wiring Regulations 17th Edition, page 94-95)

Visual inspection

The installation must be visually inspected before testing begins. The aim of the visual inspection is to confirm that all equipment and accessories are undamaged and comply with the relevant British and European Standards, and also that the installation has been securely and correctly erected.

Connection of conductors

- Identification of conductors
- Routing of cables in safe zones
- Selection of conductors for current carrying capacity and volt drop
- Connection of single-pole devices for protection or switching in phase conductors only
- Correct connection of socket outlets, lamp holders, accessories and equipment
- Presence of fire barriers, suitable seals and protection against thermal effects
- Methods of 'basic protection' against electric shock, including the insulation of live parts and placement of live parts out of reach by fitting appropriate barriers and enclosures
- Methods of 'fault protection' against electric shock including the presence of earthing conductors for both protective bonding and supplementary bonding.
- Prevention of detrimental influences (e.g. corrosion)
- Presence of appropriate devices for isolation and switching
- Presence of under voltage protection devices
- Choice and setting of protective devices
- Labelling of circuits, fuses, switches and terminals
- Selection of equipment and protective measures appropriate to external influences
- Adequate access to switchgear and equipment
- Presence of danger notices and other warning

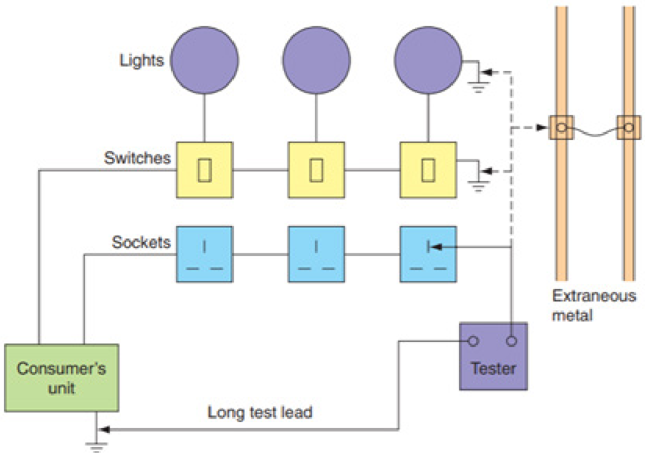
notices

- Presence of diagrams, instruction and similar information
- Appropriate erection method.

Before the supply is connected.

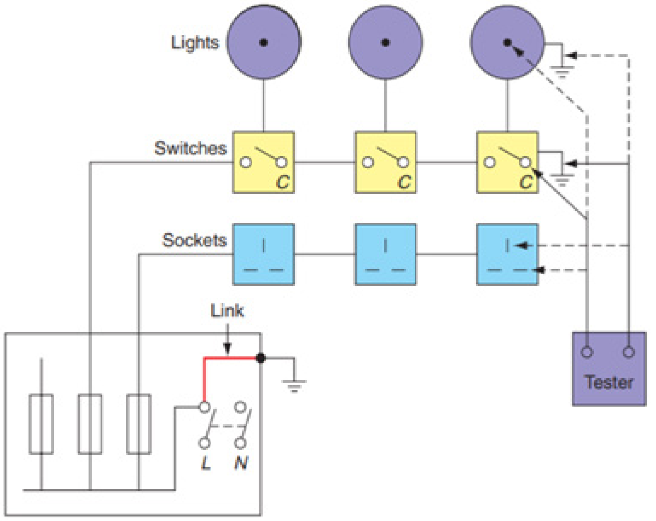
Test for continuity of protective conductors, including protective equipotential and supplementary bonding.

- Test the continuity of all ring final circuit conductors.
- Test for insulation resistance.
- Test for polarity using the continuity method.
- Test the earth electrode resistance. With the supply connected
- Recheck polarity using a voltmeter or approved test lamp.
- Test the earth fault loop impedance.
- Carry out functional testing (e.g. operation of RCDs).



(Source: Kolhe, M (2015) Wiring Regulations 17th Edition, page 98)

A D.C test using an ohmmeter continuity tester is suitable where the protective conductors are of copper or aluminum up to 35 mm.2 The test is made with the supply disconnected, measuring from the consumer's main protective earthing terminal to the far end.



(Source: Kolhe, M (2015) Wiring Regulations 17th Edition, page 103)

The test is done with the supply disconnected using an ohmmeter or continuity tester as follows:

1. Switch off the supply at the main switch.
2. Remove all lamps and appliances.
3. Fix a temporary link between the line and earth connections on the consumer's side of the main switch.
4. Test between the 'common' terminal and earth at each switch position.
5. Test between the centre pin of any Edison screw lamp holders and any convenient earth connection.

Sample Exercise

1. Briefly explain why an electrical installation needs protective devices.
2. List the four factors on which the selection of a protective device depends.
3. List the five essential requirements for a device designed to protect against overcurrent.
4. Briefly describe the action of a fuse under fault conditions.
5. State the meaning of discrimination as applied to circuit protective devices.
6. Use a sketch to show how discrimination can be

applied to a piece of equipment connected to a final circuit.

7. List typical exposed parts of an installation.
8. List typical extraneous parts of a building.
9. Use a sketch to show the path taken by an earth fault current.

6.5 MAINTENANCE OF DOMESTIC ELECTRICAL APPLIANCES

ANALYSING ELECTRICAL QUANTITIES

Job safety:

- Keep workbench and placed clean.
- Observe all safety rules and measures.
- Report any accident however slight.
- Have all injury properly treated however minor.

Procedures

Measuring instrument, millimeter or ohmmeter.

See fig. 2.1(a), (b)

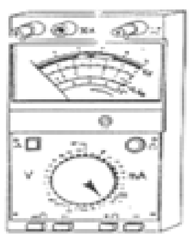


Fig 1 Multimeter

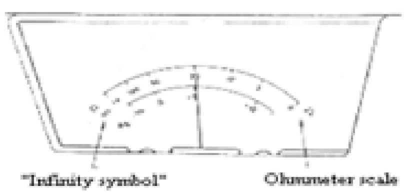


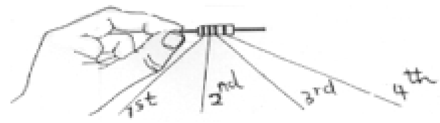
Fig 2 Ohmmeter

Types of resistors: -

- Resistor is a component, which is made to offer opposition to the flow of electrons

a. High-dissipation vitreous enameled wire wound tubular resistors
b. Fixed resistors
c. Carbon composition
d. Film-type resistors

- Connect a meter parallel with a resistor to be measured



Job Safety:

- Think before you act, and ask if in any doubt.
- Keep your bench and working area tidy.

Fig. 2.1 working area.

- Wear gloves when handling rough materials. See fig. 2.2

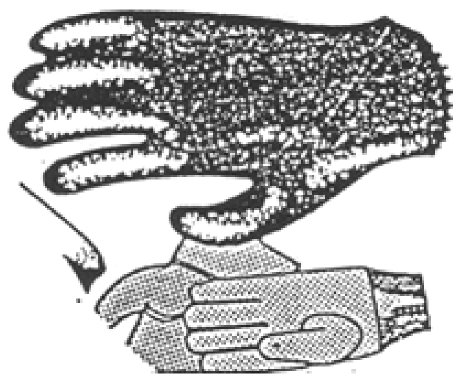


Fig. 2.2 Gloves

- Select the right tool for the right job.
- Do not work alone in the electrical laboratory or workshop. See fig. 2.3
-

Fig. 2.3 Work together

- Make connection of voltmeter parallel with the circuit.
- Put on the switch
- Take readings across the load. See fig. 2.22

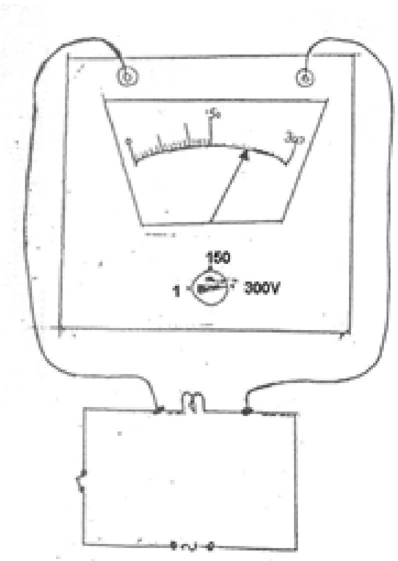


Fig. 2.22 taking readings

- Clean the working areas: - see fig. 2.23

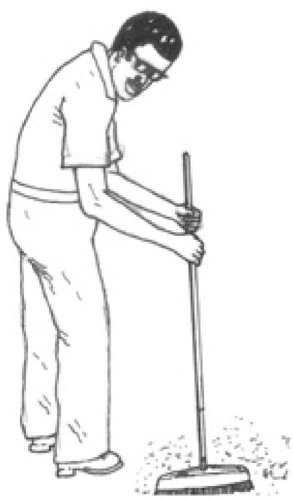
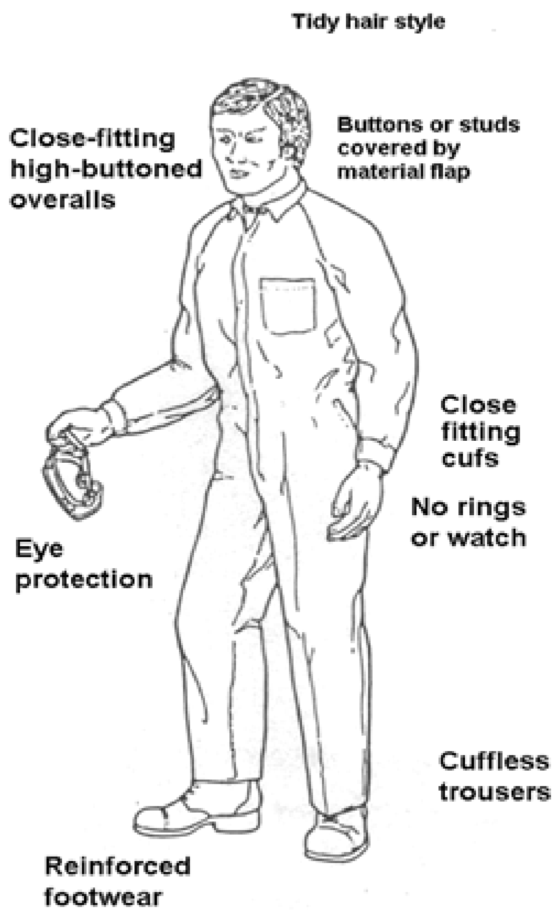


Fig. 2.23

- If you have damaged an instrument or discover any damage on it, inform your teacher immediately.
- Always keep test leads in good condition. Report any damage or defects.
- Make sure you know where the emergency switch is located.
- Wear safety clothing, goggles and protective shoes. See fig. 2.4
- Tidy hair style (Fig. 2.4 wear safety gears)



- Use the barrier cream provided.
- Wear your overalls buttoned up.
- Roll up your overall sleeves above the elbows or button up the cuffs.

2. Procedures

- Multimeter: an instrument used to measure voltage, current and resistance. See fig. 2.5

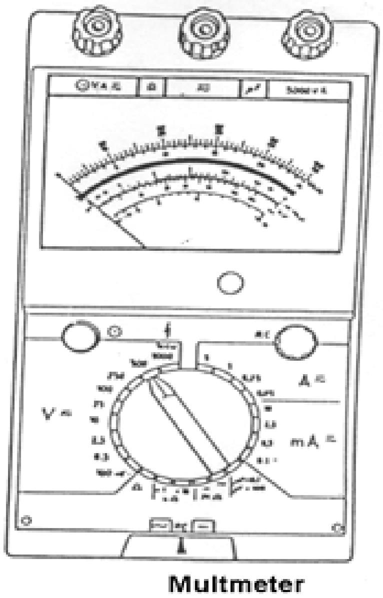


Fig. 2.5

- Voltmeter: an instrument used to measure voltage of the circuit fig. 2.6

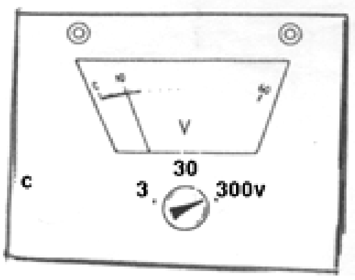
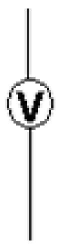


Fig. 2.6

- Symbol for voltmeter see fig 2.7



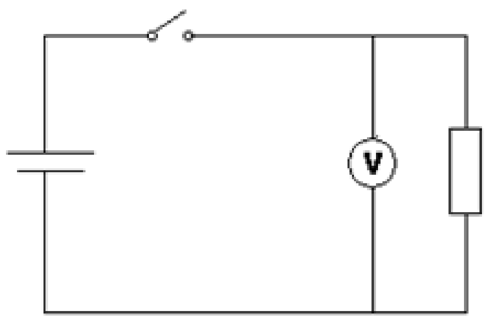


Fig. 2.8

- Voltage: the force, which drives free electronics in an electronic circuit. The unit for voltage is volt. Its unit symbol is V.
- Electric circuit is a complete path of flow of electrons. See fig 2.8
- A voltmeter is connected in parallel with a load (measured object)

3. Tools and materials

- Cutting pliers (side cutter): for cutting small size of wires. See fig. 2.9

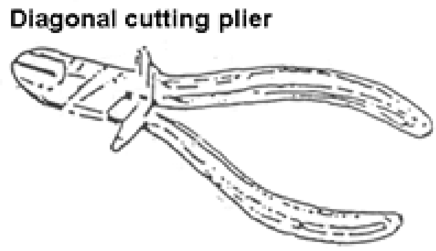


Fig. 2.9 cutting pliers (side cutter)

- Combination pliers: for cutting, twisting and removing insulation of the conductor. See fig. 2.10

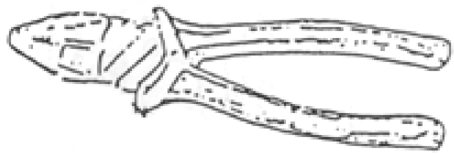


Fig. 2.10 combination plier

- Electrician's knife: for removing insulation. See fig. 2.11

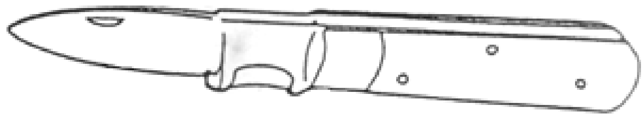


Fig. 2.11 Electrician knife

- Screw drivers: for tightening and loosening screws in an object. See fig. 2.12

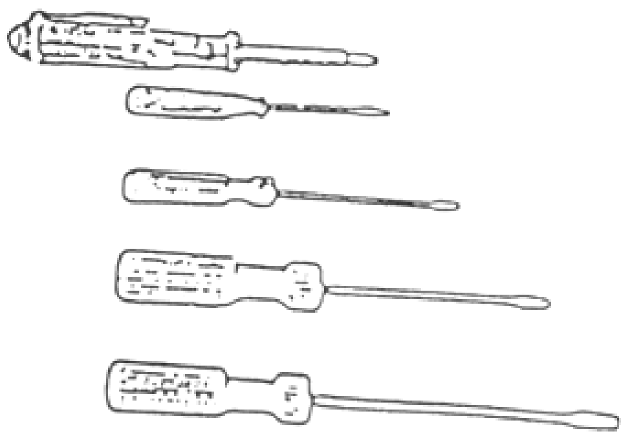


Fig. 2.12 Set of screw drivers

- Wire stripper: for removing the insulation from small and medium size PVC and rubber insulated wires. See fig. 2.13

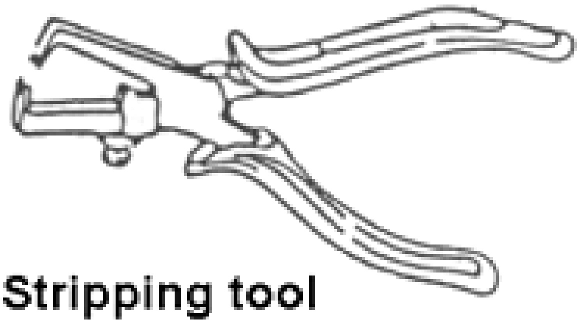


Fig. 2.13 Wire stripper

- Claw hammer: the flat face of this hammer is used mostly for nailing work. Also used to remove nails. See fig. 2.14

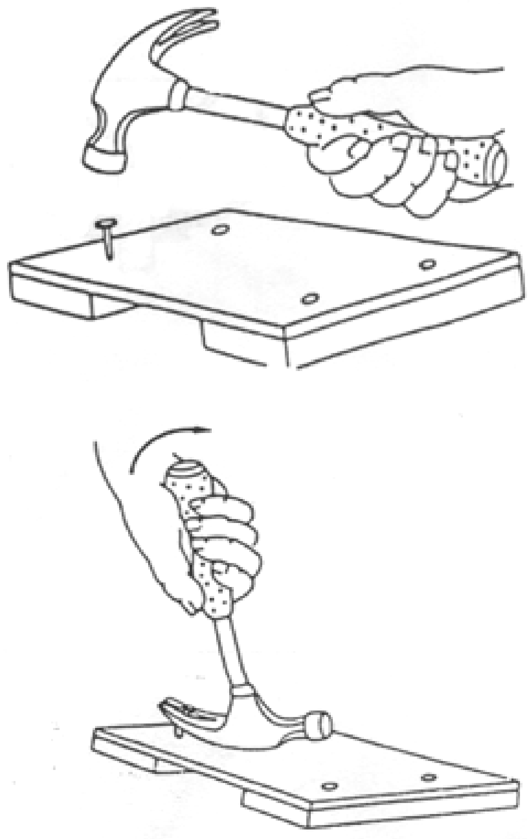
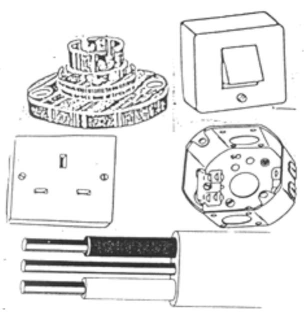


Fig. 2.14 Hammer on job

- Materials: - Lamp holder, switches, sockets, cables. See fig. 2.15



Working steps: -

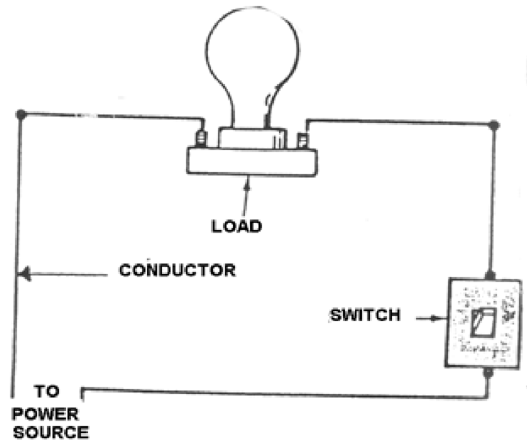
- Prepare cable. See fig. 2.16

Fig. 2.16 prepared cable

- Remove insulation by electrician knife or by wire stripper see fig. 2.17

Fig. 2.17 insulation removed

- Draw and install a simple circuit (see fig.2.18)



- Set a selector switch to the highest range. (See fig. 2.20

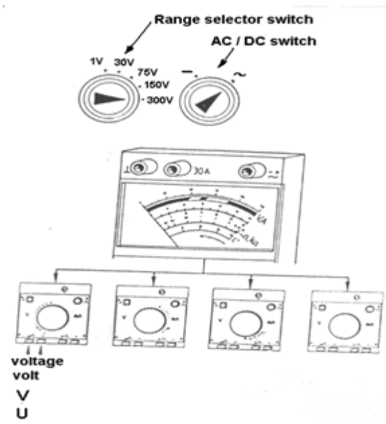


Fig. 2.20 select highest range

Automatic Electronic Rice Cooker

When using this rice cooker, basic safety precautions should always be followed including the following:

1. Read all instructions.
2. Do not touch hot surfaces. Use knobs or handles.
3. To protect against electrical hazards do not im-

merse cord, plugs, or rice cooker with warmer in water or any other liquids. Only the lid and pot may be immersed.

4. Close supervision is necessary when any appliance is used by or near children.
5. Unplug from wall outlet when not in use or before cleaning. Allow to cool before putting on or taking off parts.
6. Do not operate this rice cooker with a damaged cord or plug or after it malfunctions, or has been damaged in any matter. Return unit to your dealer. Ask him to obtain a Return Goods Authorization (RGA) number to return the rice cooker to the factory for examination, repair or adjustment.
7. The use of any non-factory supplied accessory attachments is not recommended and may cause damage.
8. Do not use outdoors.
9. Do not allow cord to hang in any way or touch hot surfaces.
10. Do not place on, near, or in heated appliances.
11. Do not attempt to move or drain unit when it contains any hot liquids.
12. Be sure power is "off" before removing plug from wall outlet.
13. Do not use this appliance for any other use not originally intended by the maker

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