ELECTRICIAN
(Power Distribution)

NSQF LEVEL - 4

2nd Year

TRADE PRACTICAL

SECTOR: POWER

(As per revised syllabus July 2022 - 1200 Hrs)

Directorate General of Training

DIRECTORATE GENERAL OF TRAINING
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
GOVERNMENT OF INDIA

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

Post Box No. 3142, CTI Campus, Guindy, Chennai - 600 032

Sector : Power

Duration : 2 Years

Trades : Electrician (Power Distribution) - Trade Practical - 2nd Year - NSQF Level - 4 (Revised 2022)

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FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of Media Development Committee members of various stakeholders viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai, has now come up with instructional material to suit the revised curriculum for **Electrician (Power Distribution) - Trade Practical - 2nd Year - NSQF Level - 4 (Revised 2022) - in Power Sector** in **Annual Pattern.** The NSQF Level - 4 (Revised 2022) Trade Theory will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF Level - 4 (Revised 2022) trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 4 (Revised 2022) the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these Instructional Media Packages IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

The Executive Director & Staff of NIMI and members of Media Development Committee deserve appreciation for their contribution in bringing out this publication.

Jai Hind

Atul Kumar Tiwari, *I.A.S*
Secretary
Ministry of Skill Development & Entrepreneurship,
Government of India.

December 2023
New Delhi - 110 001

PREFACE

The National Instructional Media Institute (NIMI) was established in 1986 at Chennai by then Directorate General of Employment and Training (D.G.E & T), Ministry of Labour and Employment, (now under Directorate General of Training, Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of Federal Republic of Germany. The prime objective of this Institute is to develop and provide instructional materials for various trades as per the prescribed syllabus under the Craftsman and Apprenticeship Training Schemes.

The instructional materials are created keeping in mind, the main objective of Vocational Training under NCVT/NAC in India, which is to help an individual to master skills to do a job. The instructional materials are generated in the form of Instructional Media Packages (IMPs). An IMP consists of Theory book, Practical book, Test and Assignment book, Instructor Guide, Audio Visual Aid (Wall charts and Transparencies) and other support materials.

The trade practical book consists of series of exercises to be completed by the trainees in the workshop. These exercises are designed to ensure that all the skills in the prescribed syllabus are covered. The trade theory book provides related theoretical knowledge required to enable the trainee to do a job. The test and assignments will enable the instructor to give assignments for the evaluation of the performance of a trainee. The wall charts and transparencies are unique, as they not only help the instructor to effectively present a topic but also help him to assess the trainee's understanding. The instructor guide enables the instructor to plan his schedule of instruction, plan the raw material requirements, day to day lessons and demonstrations.

IMPs also deals with the complex skills required to be developed for effective team work. Necessary care has also been taken to include important skill areas of allied trades as prescribed in the syllabus.

The availability of a complete Instructional Media Package in an institute helps both the trainer and management to impart effective training.

The IMPs are the outcome of collective efforts of the staff members of NIMI and the members of the Media Development Committees specially drawn from Public and Private sector industries, various training institutes under the Directorate General of Training (DGT), Government and Private ITIs.

NIMI would like to take this opportunity to convey sincere thanks to the Directors of Employment & Training of various State Governments, Training Departments of Industries both in the Public and Private sectors, Officers of DGT and DGT field institutes, proof readers, individual media developers and coordinators, but for whose active support NIMI would not have been able to bring out this materials.

Chennai - 600 032 **EXECUTIVE DIRECTOR**

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisation to bring out this IMP for the trade of **Electrician (Power Distribution) - 2nd Year - Trade Practical - NSQF Level - 4 (Revised 2022)** under the **Power** Sector for ITIs.

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NIMI records its appreciation of the Data Entry, CAD, DTP Operators for their excellent and devoted services in the process of development of this Instructional Material.

NIMI also acknowledges with thanks, the invaluable efforts rendered by all other staff who have contributed for the development of this Instructional Material.

NIMI is grateful to all others who have directly or indirectly helped in developing this IMP.

INTRODUCTION

TRADE PRACTICAL

The trade Practical manual is intented to be used in workshop . It consists of a series of practical exercises to be completed by the trainees during the 2nd year course of the **Electrician (Power Distribution)** under **Power Sector.** Trade supplemented and supported by instructions/ informations to assist in performing the exercises. These exercises are designed to ensure that all the skills in compliance with NSQF Level - 4 (Revised 2022) syllabus are covered.

This manual is divided into Twelve modules. The Twelve modules are given as below

Module 1	-	**Control Cabinets and Equipments**
Module 2	-	**Power Generation Equipments**
Module 3	-	**Testing & Maintenance Transformer**
Module 4	-	**LT/HT Cables**
Module 5	-	**Control Elements**
Module 6	-	**Earthing**
Module 7	-	**OH Distribution Line, ABC System, HVDS**
Module 8	-	**Tower/Pole Accessories**
Module 9	-	**Energy Meter, Log Sheet Energy Accounting**
Module 10	-	**Substation Equipment Panels**
Module 11	-	**Power & Control Circuits, Drawings**
Module 12	-	**Fire Fighting Equipments**

The skill training in the shop floor is planned through a series of practical exercises centred around some practical project. However, there are few instances where the individual exercise does not form a part of project.

While developing the practical manual a sincere effort was made to prepare each exercise which will be easy to understand and carry out even by below average trainee. However the development team accept that there is a scope for further improvement. NIMI, looks forward to the suggestions from the experienced training faculty for improving the manual.

TRADE THEORY

The manual of trade theory consists of theoretical information for the two years course of the **Electrician (Power Distribution)** Trade Practical NSQF Level - 4 (Revised 2022) under **Power Sector**. The contents are sequenced according to the theory exercise contained in NSQF Level - 4 (Revised 2022) syllabus on Trade Theory attempt has been made to relate the theoretical aspects with the skill covered in each exercise to the extent possible. This correlation is maintained to help the trainees to develop the perceptional capabilities for performing the skills.

The Trade theory has to be taught and learnt along with the corresponding exercise contained in the manual on trade practical. The indicating about the corresponding practical exercise are given in every sheet of this manual.

It will be preferable to teach/learn the trade theory connected to each exercise atleast one class before performing the related skills in the shop floor. The trade theory is to be treated as an integrated part of each exercise.

The material is not the purpose of self learning and should be considered as supplementary to class room instruction.

CONTENTS

LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

S.No.	Learning Outcome	Ref. Ex.No.
1	Assemble accessories and carry out wiring of control cabinets and equipment. (Mapped NOS: PSS/N1707)	2.1.133 - 2.1.137
2	Perform on-site installation, preventive maintenance, testing, repair/ replacement of electrical power distribution equipment viz., circuit breakers, isolators, lightening arresters, reactor, capacitor bank etc. (Mapped NOS: PSS/N1708, PSS/N0106)	2.2.138 - 2.2.158
3	Carry out testing, maintenance and evaluate performance of transformers. (Mapped NOS: PSS/N2407)	2.3.159 - 2.3.178
4	Plan and prepare LT/HT cable and Underground cable joints. (Mapped NOS: PSS/N0108)	2.4.179 - 2.4.191
5	Perform testing, repair/ replacement and maintenance of control elements viz., CT, PT, etc., used for protection and measurement in power distribution. (Mapped NOS: PSS/N1707)	2.5.192 - 2.5.208
6	Plan and prepare Earthing installation, carryout testing and maintenance. (Mapped NOS: PSS/N6002)	2.6.209 - 2.6.218
7	Plan and commission overhead distribution line including ABC and HVDS. (Mapped NOS: PSS/N0108)	2.7.219 - 2.7.226
8	Carry out installation, repair/ replacement and maintenance of tower/pole and accessories in Power Distribution System. (Mapped NOS: PSS/N0108)	2.8.227 - 2.8.235
9	Monitor meter readings, generate bill, maintain & upkeep various log sheets and energy accounting. (Mapped NOS: PSS/N3001)	2.9.236 - 2.9.241
10	Examine the faults and carry out repairing of substation equipment and panels. (Mapped NOS: PSS/N2503, PSS/N2505)	2.10.242 - 2.10.249
11	Read and understand electrical Schematic drawings of power and control circuits of outdoor substation. (Mapped NOS: PSS/N2503)	2.11.250 - 2.11.252
12	Read and understand electrical Schematic drawings of power and control circuits of outdoor substation. (Mapped NOS: PSS/N2503)	2.12.253 - 2.12.254

SYLLABUS

2nd Year **Duration: Two years**

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With indicative hour)	Professional Knowledge (Trade Theory)
Professional Skill 55 Hrs; Professional Knowledge 15Hrs	Assemble accessories and carry out wiring of control cabinets and equipment. **(Mapped NOS: PSS/ N1707)**	133. Carry out wiring of control cabinet as per wiring diagram, bunching of XLPE cables, channelling, tying and checking etc. (15Hrs) 134. Mount various control elements e.g. circuit breakers, relays, contactors and timers etc. (12Hrs) 135. Identify and install required measuring instruments and sensors in control panel. (08Hrs) 136. Test the control panel for its performance. (08Hrs) 137. Design layout of control cabinet, assemble control elements and wiring accessories for: (i) Forward and reverse operation of induction motor. (06Hrs) (ii) Automatic star-delta starter with change of direction of rotation. (06Hrs)	Study and understand Layout drawing of control cabinet, power and control circuits. Various control elements: Isolators, pushbuttons, switches, indicators, MCB, fuses, relays, types of timers and limit switches etc. Wiring accessories: Race ways/ cable channel, DIN rail, terminal connectors, thimbles, lugs, ferrules, cable binding strap, buttons, cable ties, sleeves, gromats and clips etc. Testing of various control elements and circuits. (15 hrs.)
Professional Skill 58Hrs; Professional Knowledge 18Hrs .	Perform on-site installation, preventive maintenance, testing, repair/ replacement of electrical power distribution equipment viz., circuit breakers, isolators, lightening arresters, reactor, capacitor bank etc. **(Mapped NOS: PSS/ N1708, PSS/N0106)**	138. Identify outdoor and indoor switchgears. (04 Hrs) 139. Identify power and distribution transformers.(04 Hrs) 140. Visit to power and motor control centre and identify various equipment. (04 Hrs) 141. Practice Live-dead-Live test in electrical panel (HV/LV). (04 Hrs) 142. Draw layout of thermal power plant and identify function of different elements. (08 Hrs) 143. Draw layout of hydel power plant and identify functions of different elements. (08 Hrs) 144. Draw single line diagram of transmission and distribution system. (08 Hrs) 145. Identify various substation equipment viz., isolators, over current relays, earth fault relay, differential relay, REF relay, lightening arresters, Surge counter, wave trap, Reactor, Capacitor bank, Circuit breakers – ACB, SF-6 and VCB etc. (14 Hrs)	Various ways of electrical power generation by conventional and non-conventional methods. Transmission and distribution networks. General layout of substation Single line diagram, general symbols for various equipment installed at substation. Single line diagram for various 33 KV, 132 KV, 220 KV, 400 KV substations. Basic idea about distribution system Electrical Safety guidelines and regulations for HT. Direct and indirect Risks of electricity. Voltage detector and its application Basic Parameters of all equipments and their name plate. Techniques of Hotline maintenance at HVS/s. Protection of transmission line via PLCC system. (18 hrs.)

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With indicative hour)	Professional Knowledge (Trade Theory)
		146. Video demonstration of laying OPGW along with earth wire at the top of tower of HV Line. (04 Hrs)	
Professional Skill 42Hrs; Professional Knowledge 15Hrs .	Perform on-site installation, preventive maintenance, testing, repair/ replacement of electrical power distribution equipment viz., circuit breakers, isolators, lightening arresters, reactor, capacitor bank etc. **(Mapped NOS: PSS/ N1708, PSS/N0106)**	147. Practice operation of isolators. (02 Hrs) 148. Identify different components of Circuit Breakers. (02hrs) 149. Perform operation of circuit breakers in maintenance (test) mode. (03hrs) 150. Practice use of grounding rod and make visible earthing. (02 hrs) 151. Practice operation of Circuit Breakers; ACB, SF-6 and VCB etc. (06 hrs) 152. Practice filling and evacuation of gas in SF-6 Circuit breaker. (03hrs) 153. Carry out timer test on circuit breakers. (02 hrs) 154. Carry out repair and maintenance of circuit breakers. (08 hrs) 155. Identify lightening arrester in the yard and practice replacement. (04 hrs) 156. Practice reading of surge counter. (02 hrs) 157. Identify Wave Trap and LMU and practice replacement. (04 hrs) 158. Carry out maintenance on wave trap and LMU. (04 hrs)	Types of isolators like Horizontal centre break, Double break, Pantograph type. Circuit Breakers; Types of circuit breakers, their applications and functioning. Production of arc and arc quenching methods (Air blast, oil, SF-6 and vacuum) Types of male and female contacts. Types of jaws & blades of various isolators Maintenance of equipment Grounding Rod Lightening arrester, surge counter Wave Trap and LMU (Line Matching Unit); power line carrier communication (PLCC) system Corona losses in transmission lines in power system. General routine maintenance. Handling of SF6 gas (filling and evacuation procedure) Inspection of contact resistance of breakers and alignment of contacts. Opening and closing time of breakers. (15 hrs.)
Professional Skill 120Hrs; Professional Knowledge 25Hrs	Carry out testing, maintenance and evaluate performance of transformers. **(Mapped NOS: PSS/ N2407)**	159. Verify terminals, identify components and calculate transformation ratio of single-phase transformers. (07Hrs) 160. Determine voltage regulation of single-phase transformer at different loads and power factors. (07Hrs) 161. Perform series and parallel operation of two single phase transformers. (07 Hrs)	Working principle, construction and classification of transformer. Single phase and three phase transformers. Turn ratio and e.m.f. equation. Series and parallel operation of transformers. Voltage Regulation and efficiency. Auto Transformer and instrument transformers (CT & PT).

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With indicative hour)	Professional Knowledge (Trade Theory)
.		162. Verify the terminals and accessories of three phase transformer HT and LT side. (05Hrs) 163. Perform 3 phase operation (i) delta-delta (ii) delta-star (iii) star-star (iv) star-delta, by use of three single phase transformers. (07Hrs) 164. Perform BDV (Dielectric strength) and water particle content test of transformer oil. (07 Hrs) 165. Video demonstration of filtering of transformer oil. (05Hrs) 166. Carry out routine tests of transformer to check operational performance. (07Hrs) 167. Carry out IR & PI test of distribution transformer used in substations using analog& digital megger. (07Hrs) 168. Measure Transformer winding resistance. (02Hrs) 169. Carry out IR test of individual bushings of distribution transformer. (03Hrs) 170. Identify phase and neutral bushings of HV & LV side of the distribution transformer. (05Hrs) 171. Identify various components of cooler control system of the transformer. (04Hrs) 172. Carry out manual and auto operation of fan from transformer marshalling kiosk. (04 Hrs) 173. Perform transformation ratio test. (04 Hrs) 174. Carry out Short circuit test and measure impedance voltage/ short circuit impedance (principal tap) and load loss. (05 Hrs) 175. Carry out Open circuit test for measurement of no-load loss and current. (10Hrs) 176. Carry out induced Voltage Test of Transformer. (08Hrs)	Method of connecting three single phase transformers for three phase operation. Types of Cooling, protective devices, bushings and termination etc. Testing of transformer oil. Routine tests and Pre-commissioning tests of transformers. On load tap changer, driving mechanism and operation of tap. Oil test include DGA (Dissolved gas analysis) and its interpretation Metal particle analysis and FURAN test Partial discharge (PD) and tan delta test. Alarm and Trip settings for winding temperature Indicator, oil temperature Indicator and Buchholz etc. On load tap changer (OLTC), Driving mechanism and operation of tap locally as well as remotely from control room. Vector group test for parallel operation of transformers. (25 hrs.)

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With indicative hour)	Professional Knowledge (Trade Theory)
		177. Carry out tests on components / accessories viz., buchholz relay, Temperature indicators, Pressure relief devices, Oil preservation system etc. (08Hrs) 178. Carry out maintenance of transformer. (08Hrs)	
Professional Skill 80Hrs; Professional Knowledge 20Hrs	Plan and prepare LT/ HT cable and Underground cable joints. **(Mapped NOS: PSS/ N0108)**	179. Identify different types of HT/LT cables. (04hrs) 180. Identify different parts of various underground cables. (04hrs) 181. Practice preparation of cables for termination and joining. (08hrs) 182. Demonstrate termination kits and practice on terminations of LT/HT cables. (08hrs) 183. Make straight joint of different types of underground cable. (10hrs) 184. Carry out high voltage (high pot) test. (06 hrs) 185. Practice laying of HT/LT cables in raceways and trenches. (06 hrs) 186. Demonstrate and identify various cable glands. (05 hrs) 187. Practice passing of cables through cable entry plate for standard cables without connectors, up to IP 68 rated protection. (05 hrs) 188. Practice split cable entry for multiple pre-terminated cables, up to IP 65 rated protection. (05 hrs) 189. Practice cable entry on a switch cabinet wall. (05 hrs) 190. Demonstrate bonding and grounding of raceways, cable assembly and panels. (05 hrs) 191. Test underground cables for faults and remove the fault. (09 hrs)	Power cables: Need of HT cables, advantages and disadvantages, various types viz., PVC, XLPE, Halogen, Optical fiber, etc. Awareness of HT/LV cable Cable insulation & voltage grades. Classification of cable on the basis of construction, voltage and current. Need for cable jointing (splicing). Need of termination kits. Joints and terminations; pre-moulded, heat shrinkable, extrusion molded joints Slip on, cold shrink terminations. Types of connectors used in the cable, current path. Methods of conductor connection, contact resistance. Precautions in using various types of cables. Galvanic corrosion and use of bimetals. Connectivity for cable screen and armour, mechanical protection Kits for joints and terminations (cold and heat shrink). HV and LV cable joint procedure. Cable termination to equipment Standards and testing; type, routine, field test Stress control Basic concept of Laying procedure and necessary step during emergency restoration and isolate faulty section of power cable in HV Electrical system. Introduction to IP ratings (Ingress protection) and IP Codes format.

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With indicative hour)	Professional Knowledge (Trade Theory)
			Importance of Bonding and grounding, various types. Testing of cables, locating faults, open circuit, short circuit and leakage in cables. (20 hrs.)
Professional Skill 55 Hrs; Professional Knowledge 15Hrs	Perform testing, repair/ replacement and maintenance of control elements viz., CT, PT, etc., used for protection and measurement in power distribution. **PSS/N1707**	192. Identify Current transformers, its specifications and carry out visual inspection. (03hrs) 193. Carry out ratio test on CT. (03 hrs) 194. Carry out Polarity test on CT. (03 hrs) 195. Check insulation resistance of CT. (03 hrs) 196. Carry out winding resistance test on CT. (03 hrs) 197. Carry out Excitation (Saturation) test on CT. (04 hrs) 198. Carry out Burden test on CT. (04 hrs) 199. Carry out knee point voltage test of protection core. (03 hrs) 200. Carry out ratio change of CT by changing taps in primary and secondary side. (04 hrs) 201. Perform installation and commissioning of current transformer. (06 hrs) 202. Identify potential transformers, its specifications and carry out visual inspection. (02 hrs) 203. Perform insulation resistance tests on PT; winding to winding and each winding to ground. (03hrs) 204. Carry out Polarity test on PT. (02hrs) 205. Perform turn's ratio test on PT. (03hrs) 206. Perform installation and commissioning of potential transformer. (04hrs) 207. Identify isolation transformers and its specifications. (03hrs) 208. Carry out repair/ replacement and maintenance of CT and PT. (02 hrs)	Instrument Transformer: Necessity/ Advantages • Difference between Power Transformer & Instrument Transformer. • Location of CT and PT in the System. • Difference between Instrument Transformers used for Protection/ Measurement Testing of CT and PT Isolation transformer Basic concept of Live tank and Dead tank CT Basic concept of CVT Various types of CT categories and burden-Cl-1/0.5/0.2, Protection CT – 5P10 etc Special Protection CT – PS class Various substations; outdoor, indoor, pole mounted, Gas insulated substation (GIS), etc. Various terms like – maximum demand, average demand, load factor, diversity factor, plant utility factor etc. (15 hrs.)

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With indicative hour)	Professional Knowledge (Trade Theory)
Professional Skill 55 Hrs.; Professional Knowledge 15Hrs.	Plan and prepare Earthing installation, carryout testing and maintenance. **(Mapped NOS: PSS/ N6002)**	209. Identify various earthing components and their specifications. (05Hrs) 210. Plan and prepare pipe earthing. (09Hrs) 211. Plan and prepare plate earthing. (09Hrs) 212. Plan and prepare grid/mesh earthing. (09Hrs) 213. Practice earthing of delta connected system. (03Hrs) 214. Practice grounding of equipment and systems. (03Hrs) 215. Perform measurement of earth resistance using earth tester. (05Hrs) 216. Carry out treatment to minimize earth resistance. (04Hrs) 217. Carry out maintenance of earth system. (04Hrs) 218. Test earth leakage by ELCB and relay. (04Hrs)	Introduction Importance of Earthing Classification of Earthing: - • Depending upon use; Equipment, System, Discharge, Support and Line Earthing. • Depending upon type; Well type, Pipe, Plate, Mesh, Delta and Chemical earthing Plate earthing and pipe earthing methods and IEE regulations. Difference between grounding and earthing. Earth resistance and earth leakage circuit breaker. Balanced/ Restricted earth protection. Awareness of circuit main earth (CME) and portable earth. (12 hrs.)
Professional Skill 100Hrs; Professional Knowledge 20 Hrs	Plan and commission overhead distribution line including ABC and HVDS. **PSS/N0108**	219. Identify various conductors viz., All aluminium conductor (AAC), ACSR conductor, etc. (08Hrs) 220. Perform mechanical and electrical testing of overhead conductors. (12 Hrs) 221. Identify various sizes of copper wires and cable insulation FR/ FRLS/FRLSH. (08Hrs) 222. Practice joining of overhead line conductors. (12 Hrs) 223. Identify Aerial Bunched Cables used in distribution system. (08Hrs) 224. Plan and commission overhead distribution line using bare conductors. (20 Hrs) 225. Plan and commission distribution line using ABC. (20 Hrs) 226. Identify components and work with High Voltage Distribution System (HVDS). (12 Hrs)	Objectives of Distribution System. Classification of Conductors and Nomenclature Current rating Jointing of conductor ABC System - Prominent Considerations for Selection for ABC System; LT ABC, HT ABC Method of joining aluminum conductors. High Voltage Distribution System (HVDS) Advantages of HVDS Route survey for overhead and underground cable distribution system. Safety Procedures and Permit to Work Operation and Maintenance of Distribution System. (20 hrs.)

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With indicative hour)	Professional Knowledge (Trade Theory)
Professional Skill 75 Hrs; Professional Knowledge 23Hrs	Carry out installation, repair/ replacement and maintenance of tower/pole and accessories in Power Distribution System. **(Mapped NOS: PSS/ N0108)**	227. Identify different Supports, Transmission Towers, and various accessories.(08 Hrs) 228. Perform digging of pit, erection of supports and fitting various accessories on poles.(12 Hrs) 229. Perform stringing and sagging of line conductors.(10 Hrs) 230. Fasten jumper in pin, shackle and suspension type insulators. (10 Hrs) 231. Perform installation of overhead domestic service lines.(15 Hrs) 232. Measure current carrying capacity of conductors. (05 hrs) 233. Practice installation and sealing of energy meters.(05 Hrs) 234. Install bus bar and bus coupler on LT line. (05 Hrs) 235. Practice working with thermo vision camera. (05 Hrs)	CEA safety regulation 2010 Supports and Accessories: PCC Pole, ST Pole, Cross Arms, Clamps, Transmission Towers Different types of Line insulators Foundations - Dry, Wet, PS, FS and Well type Construction of Distribution and Transmission Network. Erection & Commissioning of Equipments. Safety precautions and IE rules pertaining to domestic service connections. Basic concept of MONO Pole, Multi circuit Tower and 90 degree crossing of two HV Transmission line in same tower. Basic concept of transposition of towers. Types of Faults in electrical system. Thermo vision supervision at substation for hot point detection. (23 hrs.)
Professional Skill 50 Hrs.; Professional Knowledge 15Hrs.	Monitor meter readings, generate bill, maintain & upkeep various log sheets and energy accounting. **(Mapped NOS: PSS/ N3001)**	236. Practice on collecting meter reading of various meters. (08hrs) 237. Practice study of MRI reports. (12 hrs) 238. Take meter reading by using USB / Optical cable. (12 hrs) 239. Observe/ Study log sheet at substation. (08 hrs) 240. Practice generation of electricity bill using SBM. (05 hrs) 241. Demonstrate shut down and work permit proformance. (05 hrs)	**Energy meters;** Types, Meter Reading, Description of MRI, General layout of Meter Test Lab. Testing of Meters, Operation of SBM (Spot billing machine) Knowledge about TOD metering **Log Sheet;** Maintenance and up keeping of daily Log Sheet at various Substation and energy accounting along with Recording of Complaints and follow-up action Shut down and work Permit. (15hrs.)
Professional Skill 75 Hrs.; Professional Knowledge 24Hrs.	Examine the faults and carry out repairing of substation equipment and panels. **(Mapped NOS:PSS/ N2503, PSS/N2505)**	242. Practice isolation procedure and switching procedure preparation. (12hrs) 243. Practice implementation of permit system and LOTO system. (12hrs)	Isolator, circuit breaker, Earth switch; Working principal and mechanism

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With indicative hour)	Professional Knowledge (Trade Theory)
		244. Identify various fuse sets viz., HRC, DO, 33KV fuse set, etc. (05 hrs) 245. Measure and select size of fuse wire. (06 hrs) 246. Practice reading of energy flow diagram. (06 hrs) 247. Examine faults in Control Room Wiring and practice repairing. (14 hrs) 248. Identify various parts of relay and ascertain the operation. (10Hrs) 249. Practice setting of pick up current and time setting multiplier for relay operation. (10 hrs)	Emergency lighting system 6 Steps of Lockout/ Tagout (LOTO), colour coding of tags and locks, different types of locks. Energy flow diagram. Necessity, Advantages / Disadvantages of fuses. Types of IT & HT fuses Drop out (DO) Fuses sets Rupturing Capacity & recommended sizes of fuse elements. Installation and maintenance. Types of relays and its operation. High power rectifier system and its application at various industries. Introduction to SCADA and GIS mapping. (24 hrs.)
Professional Skill 50 Hrs.; Professional Knowledge 15Hrs.	Read and understand electrical Schematic drawings of power and control circuits of outdoor substation. **PSS/N2503**	250. Interpret Single line/ Layout drawings with Equipment and Protection codes as per ANSI. (15 hrs) 251. Interpret Layout drawings of 400kV/220kV/132kV/66kV/33kV/ 11kV outdoor substations. (15 hrs) 252. Interpret various panel wiring drawings of substation equipment. (20 hrs)	Power and control schematic drawings with interlocks. Isolator and Earth switch wiring, PT terminal box wiring CT terminal box wiring Circuit breaker closing and tripping circuits, Marshalling box wiring, Relay and control panel wiring. RTCC panel wiring. OLTC panel wiring. Mimic panel wiring. (15 hrs.)
Professional Skill 25 Hrs.; Professional Knowledge 06Hrs.	Operate firefighting equipment and systems used in substation. **PSS/N2001**	253. Identify various fire fighting equipment used in substations. (05 hrs) 254. Practice on different fire fighting extinguishers. (20 hrs)	**Fire Fighting;** Categories of Fire-A, B, C, D & E - General description Description Fire Fighting Equipments Suitable for various categories of fire. Electrical Fire; Origin and Preventive Measures Do's and Don'ts for Electrical Safety. Fire protection system: Various type of system used in the Electrical distribution system. (06 hrs.)

Carryout wiring of control cabinet as per wiring diagram, bunching of XLPE cables channeling, tying and checking etc

Objectives: At the end of this exercise you shall be able to
- **verify the wiring diagram panel board and wire up**
- **bunch the Cross Linked Polyethylene (XLPE) cables**
- **channel and tie the cables**
- **check the wiring.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 No.
- Multimeters - 1 No.
- Wire cutter/stripper - 1 No.

Materials

- Panel board - 3'x2'x1' - Metal box with winged front door - 1 No.
- DIN rails/race ways - as reqd.
- Screws, nuts and bolts - as reqd.
- Tying clips - as reqd.
- Ferrule - as reqd.
- PVC channel - as reqd.
- G channel - as reqd.
- Terminal connector - as reqd.
- Belt traps - as reqd.
- XLPE cable 1.5 sq.mm 600V - as reqd.
- 1 sq.mm cable (copper) - as reqd.
- Wire sleeves - as reqd.
- Wire clips - as reqd.
- Grommets - as reqd.
- Banana sockets (5 mm) - 1 No.

PROCEDURE

TASK 1 : **Wire up control cabinet as per diagram with bunching, channeling, typing and checking etc**

1 Draw the wiring diagram and wire up as per the diagram.

Follow the colour coding of cables used for line controller, neutral and ground connections.

Inter connections of devices may be used same colour. Supply line, load line should he colour coded and numbered using ferrule.

2 Bunch the XLPE cables by using the tie clips and wire clips.

3 Apply belt traps for excessive bunch of cables.

4 Make a U loop on the bunch of cables when it is connected to front door.

5 Cut excessive tie ends and other excessive parts to make a neat bunching of cables.

6 Show the work done on the panel board to your instructor and get approval.

7 Check the wiring for its correctness.

— — — — — — — —

TASK 2 : **Connect the control panel with 3 phase induction motor**

1 Draw the circuit diagram for the control panel with 3 phase induction motor. (Fig 1)

2 Wire up the control panel to the 3 phase motor in conduct wiring.

3 Provide double earthing for the motor.

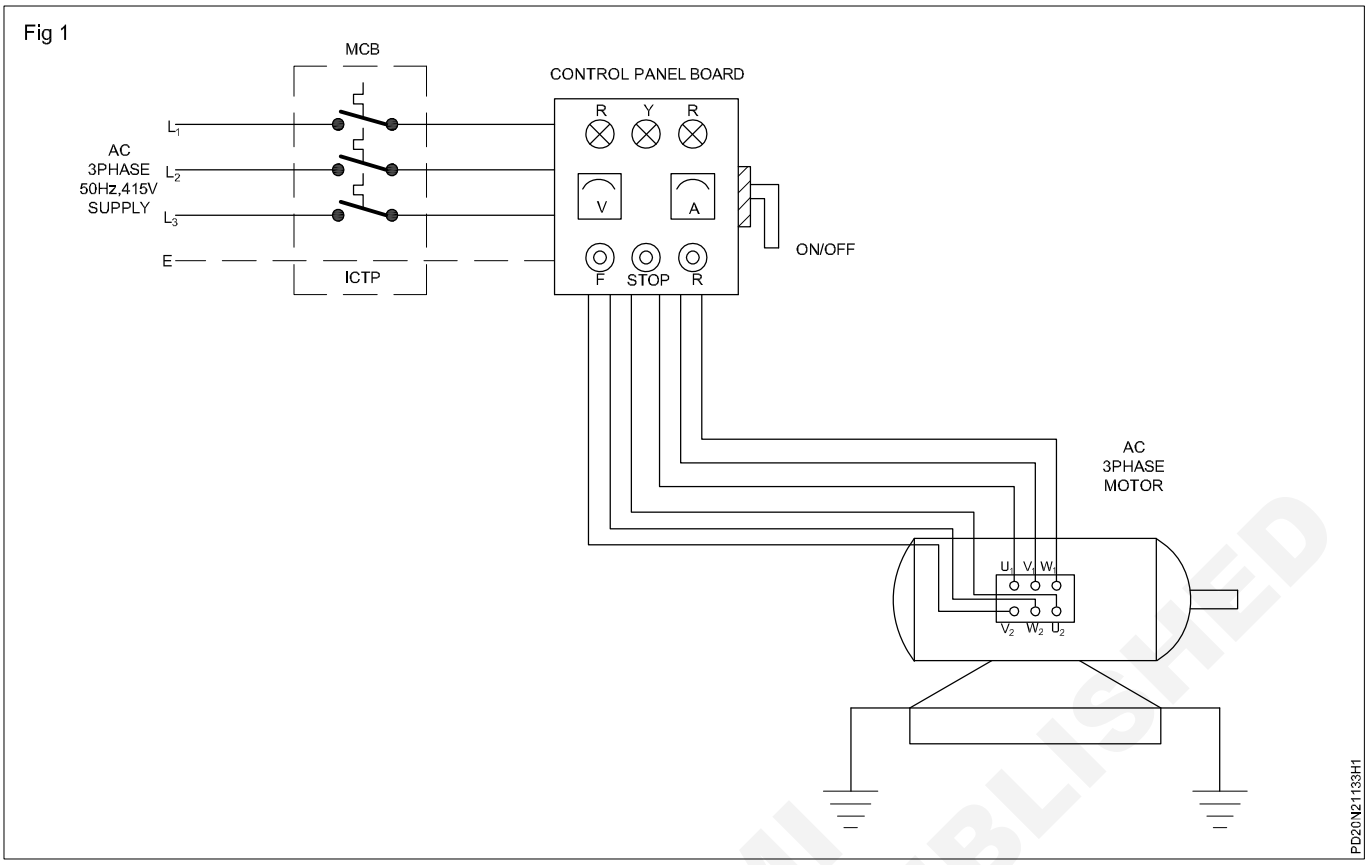
4 Test the wiring for the proper operation of control panel controls with motor.

5 Check the controls of control panel for changing the direction of rotation of motor.

6 Get it checked with your instructor.

— — — — — — — —

Fig 1



Mount various control elements (e.g) circuit breakers, relays, contactors and timers etc

Objectives: At the end of this exercise you shall be able to
- **drill the holes in the marked places**
- **Mount the circuit breakers, relays, contactors and timer**
- **connect the cables to the control elements.**

Requirements

Tools/Equipments/Machines

- Trainees tool kit - 1 No.
- Multimeter - 1 No.
- Wire cutter/striper - 1 No.
- Needle file set - 1 Set.
- Round file set - 1 No.
- Hand drilling machine (electric) 6mm - 1 No.
- Half round file smooth-150 mm - 1 No.
- Flat file smooth-150 mm - 1 No.

Materials

- MCB 4 pole, 415V/16A - 1 No.
- OLR- 3 phase 415V/0-15A - 1 No.
- Contactors - 3 phase, 415V/16A 240V coil - 5 Nos.
- Timer - 1 phase, 10 sec - 2 Nos.
- Push button - 240V, NC/NO red & green - 4 Nos
- Indicating lamp with holder RYB - 3 Nos.
- Limit switch - 1 No.
- ON-OFF rotary switch 3 phase 32A - 1 No.

PROCEDURE

TASK 1: **Mark and make holes for mounting devices**

1 Measure the total area of base plate on four panel board, where devices are to be mounted.

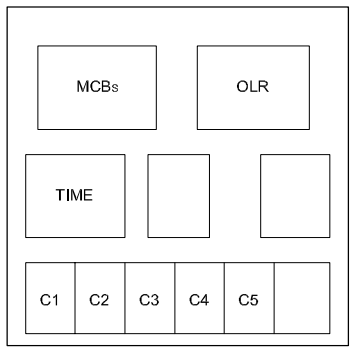
2 Identify and check the area required to mount the devices like circuit breaker, contactor, push button, OLR, ON-OFF rotary switch, Timer, etc: as per the total quantity available.

3 Mark the plates where to fix the DIN rail and race ways to mount circuit breaker, contactors. (Fig 1)

While marking the layout for mounting devices, it is distributed equally to the whole area uniformly. Do not fix all the items in one end. Keep some space for future needs.

4 Make hole by electric drill to the size of nut and bolts. If the bolt is not free in through holes, use needle round file or bigger bits to make the bolt free going.

Fig 1



LAYOUT OF CONTROL DEVICES ON BASE PLATE

5 Fix the devices according to the layout on base plate check each devices for its rigidity and position correctness and get it checked.

— — — — — — — —

TASK 2: **Connect cables to control devices and checking the continuity**

1 Check the XLPE cables for continuity and tighten before connecting to the device.

2 Connect all the cable to the respective terminals and connecting points to the devices, fitted on the base plate.

3 Connect the relay coil, contactor coil, etc to a external source of working voltage and confirm the function especially in the Normally Close (NC) and Normally Open (NO) no contacts of push buttons and contactors.

4 Report to your instructor for approval.

— — — — — — — —

Identify and install required measuring instruments and sensors in control panel

Objectives: At the end of this exercise you shall be able to
- **identify and fix instruments to measure electrical quantities**
- **identify the sensors and fix it on the panel board.**

Requirements

Tools/Equipments/Machines

- Trainees tool kit - 1 No.
- Wire cutter/striper - 1 No.
- Hard drilling machine (electrical) 6mm - 1 No.
- Needle file set (set of 5) - 1 Set.
- Round file smooth - 150 mm - 1 No.
- Flat file smooth - 150 mm - 1 No.
- Tachometer - digital - 3 1/2 digit along with tacho generator set - 1 No.
- Single phase frequency meter digital - 3 1/2 digit - 1 No.
- Temperature indicator - digital 3 1/2 digit - along with thermistor sensor unit - 1 No.
- Voltmeter - 0-600V - digital - 1 No.
- Voltmeter - 0-300V - digital - 1 No.
- Ampere meter 0-30A digital 31/2 digit - 3 Nos.

Materials

- Nut and bolt (Assorted sizes) - as reqd.
- Washer (Ordinary & spring type) difficult sizes - as reqd.
- 1 sq.mm cable - as reqd.

PROCEDURE

The panel board used in the Ex.No.2.8.169 is to be used for this exercise with accessories.

TASK 1: **Fix panel meters and indicators on front panel**

1 Identify and select proper range of instruments (voltmeter, ammeter etc.,) suitable for this control panel.

2 Identify and select the required sensors (for temperature and speed) for this control panel.

The control devices are fitted on base cover and indicators are to be fitted on front panel. Wiring is terminated in respective points to be connected in the instruments. Proper sockets for terminating sensor outputs are to be provided on the front panel.

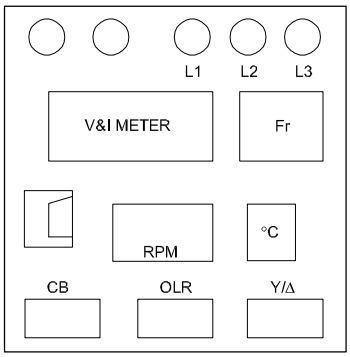
3 Mark the positions to fix the indicators on front panel (Line indicators, tripping indicators etc.)

4 Make holes for fixing the meters and other fixtures on front panel.

5 Fix the meters and indicators on front panel.

Distribution of gadgets on fixing in front panel should be uniform. Proper arrangement and distribution to have a good look on the front panel required. Do not crowed the devices at one places, and indicate devices like line indicator, trip indicator should be at top of the front panel as in Fig 1.

Fig 1



LAYOUT OF DEVICES ON FRONT PANEL

6 Wire the fitting in front panel using suitable cables.

Bunching or typing cables in front panel board is to be done if necessary.

7 Check the continuity of cables wired inside the panel board.

8 Report to your instructor.

Test the control panel for its performance

Objectives: At the end of this exercise you shall be able to
- **test the control panel for any short circuit earthing with fitted devices**
- **test the earthing points connections with connected control devices**
- **energise and test the panel board for its working condition.**

Requirements

Tools/Equipments/Machines

- Trainees tool kit - 1 No.
- Megger 1000V - 1 No.

Materials

- Connecting leads - as reqd.

PROCEDURE

The panel board used for the Ex.No. 2.8.170 is to be used for this Exercise with complete accessories and wiring.

The panel board with accessories and wiring is to be preserved for this Exercise No.2.8.171

1 Check the Insulation Resistance (IR) value of contactors circuit breakers etc, (Fig 1) enter the values in Table 1.

2 Check for any short circuit/open circuit fault.(Fig 1)

If any IR value shows abnormal or very low, consult with your instructor.

3 Switch 'ON' the supply to the panel board and verify the functions of line indicator, meters etc.

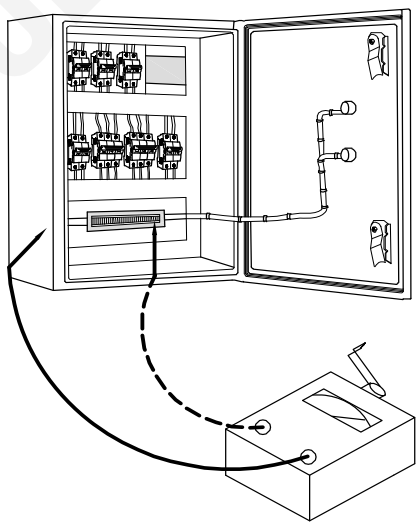
4 Test the contactor, push button switch, timer for its function. Enter the status in Table 1.

5 Switch 'ON' the motor and check the functions of sensors (speed and temperature)

If any control device found faulty replace new control devices and test it.

6 Complete your testing and show to your instructor for approval.

Fig 1



TESTING OF PANEL BY MEGGER

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Table 1

Sl.No	Description of the items	Megger value in MΩ	Condition OK / not OK
1	Overload relay		
2	Contactor		
3	Circuit breaker		
4	Voltmeter		
5	Ammeter		
6	Frequency meter		
7	Temperature indicator		
8	Tachometer/revolution counter		
9	Indicators		

Design layout of control cabinet, assemble control elements and wiring accessories for forward and reverse operation of induction motor

Objectives: At the end of this exercise you shall be able to
- **draw the control and power circuit for forward and reverse operation of motor**
- **mark the layout on control panel**
- **wire up the accessories**
- **arrange the wiring by routing, bunching and tying**
- **test the control panel for forward and reverse of induction motor.**

Requirements

Tools/Instruments

• Trainees tool kit	- 1 No.
• Scriber 100 mm	- 1 No.
• Hacksaw frame with blade- 300 mm	- 1 No.
• Hand drilling machine 6mm capacity	- 1 No.
• HSS Drill bit 6mm & 3mm	- 1 No. each
• Round nose plier 150 mm	- 1 No.
• Crimping tool 200 mm	- 1 No.

Instruments/Equipments

• Digital multimeter	- 1 No.
• Megger 500V	- 1 No.
• Air break contactor 4pole, 16A, 240V	- 2 Nos.
• Overload relay 15A, 415V	- 1 No.

Materials

• Push button red /green/yellow	- 1 each
• Indicator lamp with holder	- 5 Nos.
• MCB 4 Pole 16A	- 1 No.
• Race ways	- 2 m
• Wire clips	- 4 Nos.
• DIN rail /G - channel	- 1 m
• 1.5 sq.mm copper cable 660V (red, black, yellow, blue, green)	- as reqd.
• Terminal connectors	- as reqd.
• Wire ferrule	- as reqd.
• Grommets	- as reqd.
• Lug/thimble	- as reqd.
• Cable binding straps and buttons	- as reqd.
• Nylon cable ties	- 10 Nos.
• Assorted size bolt and nut	- as reqd.

PROCEDURE

The control panel board used in the Ex.2.1.137 (i) has to be retained with accessories fitted to use for this Exercise.

TASK 1 : **Draw the layout and mark the layout in control panel**

1 Draw the layout diagram for the forward and reverse control of induction motor.

2 Select and check the accessories required.

3 Mark the layout inside the control panel by using steel rule and scriber for the additional accessories.

4 Mark holes for fixing control for accessories etc., as per layout diagram. (Fig 1)

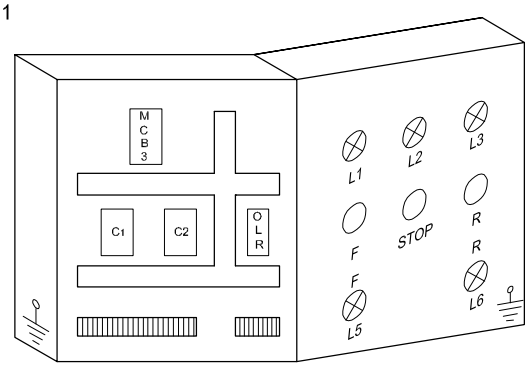
5 Mark and cut the DIN rail, 'G' channel and race ways as per layout. Mark the points of drills on it to fix them inside the control panel.

6 Mark the drill holes in the front door of the control panel to fix the indicator lamp and push button switches.

7 Mark the holes for fixing the wire clips in the control panel door to run the wires.

8 Fix the control accessories, race ways, DIN rails and 'G' channel using fixing screw and bolt nuts.

Fig 1



TYPICAL LAYOUT FOR CONTROL CABINET

9 Make the drills on the door of panel for indicator lamp, push button and wire clips.

TASK 2 : **Wire the control and power circuit for forward and reverse (F/R) control of induction motor**

1 Draw the control and power circuit and check the correctness. (Fig 1 & 2)

2 Label the Terminal number in the control and power circuit.

3 Measure and cut the cable as per layout.

A typical control panel fitted with race ways, DIN rails, control transformer and isolator etc.

4 Insert the ferrule Nos at the both ends of terminals as per layout.

Leave some extra length of wires in the race ways for easy maintenance and repair.

5 Run the wires in the race ways one by one. Avoid the cross over of the wires.

To avoid the cross-over, run the vertical wire first, followed by horizontal runs.

6 Skin the wire ends and crimp with suitable lugs/ thimbles

7 Connect the control and power circuits as per circuit diagram.

8 Route the wires in the race ways. Punch and ties the wires in the race ways using cable binding straps and button.

Leave the excess wires if any in the bends or in the race ways.

9 Cover the PVC race ways over the wiring.

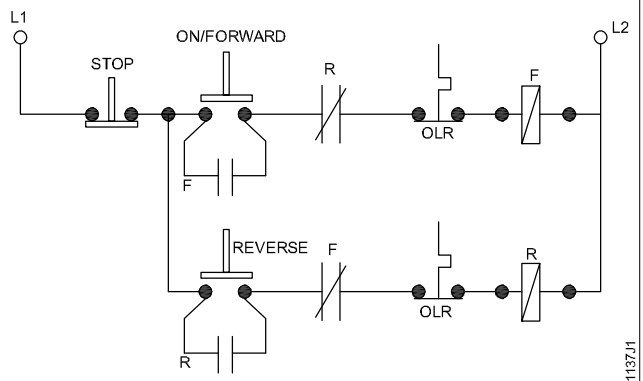
Take the necessary care to avoid the crushing of cable when cover the race ways.

10 Make the "U" loops of wires in the hinged doors. Bunch and tie the cable on the doors.

11 Fix the wire clips at suitable places to hold the cables in the panel door.

Ensure the 'U' loop should not disturb the movement and closing of the panel door.

Fig 1



CONTROL CIRCUIT FOR FORWARD AND REVERSE OPERATION

12 Connect the incoming and out going terminals as per diagram and terminal details.

Use the grommets to avoid the strain in the cables.

13 Earth the panel, door and metal devices.

14 Measure the insulation resistance of the panel.

If the IR value is less than 1 Meg ohm, take suitable remedial action.

15 Set the Over Load Relay (OLR) in accordance with the full load current of motor.

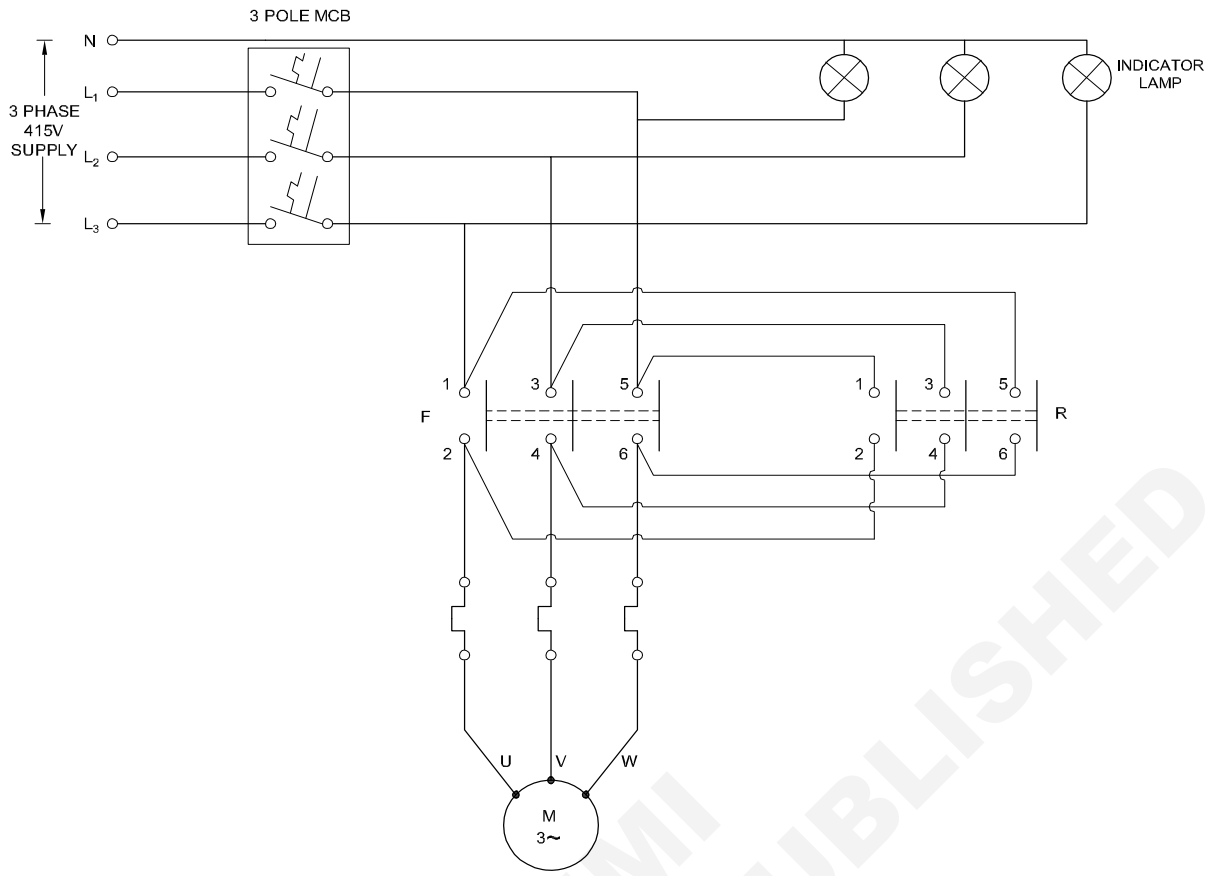
16 Test the control panel for forward and reverse of induction motor operation.

17 Check the proper functioning of indicating lamps when motor is in operations.

18 Show the control panel (F/R) working to your instructor for approval.

Note : Remove the wiring you did in the Ex.2.8.167(i) and preserve the remaining devices fitted for the next Exercise 2.1.137(iii)

Fig 2



POWER CIRCUIT DIAGRAM

Design layout of control cabinet, assemble control elements and wiring accessories for automatic star-delta starter with change of direction of rotation

Objectives: At the end of this exercise you shall be able to
- **draw the control and power circuit of automatic star delta starter with change of direction of rotation**
- **mark the layout on control panel**
- **mount the DIN rail and accessories**
- **wire up the accessories**
- **arrange the wiring by routing, bunching and tying**
- **test the control panel for automatic star-delta starter with change of direction of rotation.**

Requirements

Tools/Instruments

• Trainees tool kit	- 1 No.
• Scriber 100 mm	- 1 No.
• Hacksaw frame with blade- 300 mm	- 1 No.
• Hand drilling machine 6mm capacity	- 1 No.
• HSS Drill bit 6mm & 3mm	- 1 No.
• Round nose plier 150 mm	- 1 No.
• Crimping tool 200 mm	- 1 No.

Instruments/Equipments

• Digital multimeter	- 1 No.
• Megger 500V	- 1 No.
• Contactor 4 pole,16A,240V,2No+2NC	- 5 Nos.
• Timer 1 No+ 1 INC relay	- 1 No.

Materials

• Push button green/red/green	- 1 each
• Indicator lamp with holder	- 5 Nos.
• Overload relay 0-15A, 415V	- 1 No.
• MCB 3 Pole 25A , 415V	- 1 No.
• Race ways	- 2 meter
• Wire clips	- 4 Nos.
• 1.5 sq.mm copper cable 650V (red, black, yellow, blue, green)	- as reqd.
• Terminal connectors	- as reqd.
• Wire ferrule	- as reqd.
• Grommets	- as reqd.
• Lug/thimble	- as reqd.
• Cable binding straps and buttons	- as reqd.
• Nylon cable ties	- 10 Nos.
• Assorted size bolt and nut	- as reqd.

PROCEDURE

The control panel board used in the Ex.No. 2.1.137 (i) has to be retained with accessories fitted to use for this exercise.

TASK 1 : **Draw the layout and mark the layout in control panel**

1 Draw the layout diagram for the automatic star delta starter with change of direction of rotation.

2 Select and check the accessories required.

3 Mark the layout inside the control panel by using steel rule and scriber.

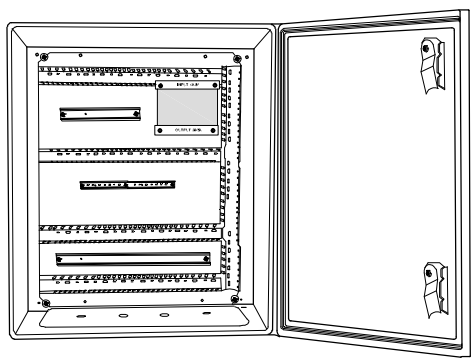
4 Mark for fixing holes for control accessories etc., as per layout diagram. (Fig 1)

5 Mark and cut the DIN rail, 'G' channel and race ways as per layout. Mark the points of drills on it to fix them inside the control panel.

6 Mark the drill holes in the front door of the control panel to fix the indicator lamp and push button switches.

7 Mark the fixing holes for the wire clips in the control panel door to run the wires.

Fig 1



CONTROL PANEL WITH RACEWAYS / DIN RAILS

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8 Make the drills in side the control panel to fix control accessories, DIN rails, 'G' channel and race ways as per marking.

9 Make the through holes in race ways, DIN rails and G channel.

10 Fix the control accessories race ways, DIN rails and G channel using screws and bolt nut.

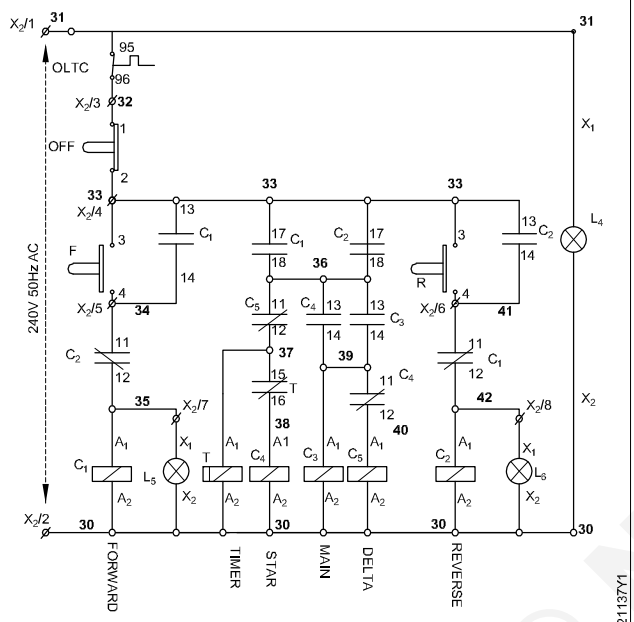
11 Make the drills on the door of panel for indicator lamp, push button and wire clips.

— — — — — — — —

TASK 2 : **Wire the control and Power circuit for automatic star delta starter with change of direction of rotation and test**

1 Draw the control circuit and power circuit diagram and check with your Instructor. (Fig 1 & 2)

Fig 1



AUTOMATIC STAR-DELTA STARTER WITH FORWARD & REVERSE-CONTROL CIRCUIT

2 Label the Terminal number in the control and power circuit.

3 Measure and cut the cable as per layout.

A typical control panel fitted with race ways, DIN rails, control transformer and isolator.

4 Insert the ferrule Nos at the both ends of terminals as per layout.

Leave some extra length of wires in the race ways for easy maintenance and repair.

5 Run the wires in the race ways one by one. Avoid the cross over of the wires.

To avoid the cross - over first the vertical wires can be run followed by horizontal run.

6 Skin the wire ends and crimp with suitable lugs/ thimbles.

7 Connect the power and control circuits wires as per the control circuit diagram.

8 Route the wires in the race ways. Punch and ties the wires in the race ways using cable binding straps and button.

Leave the excess wires if any in bends or in the race ways.

9 Cover the PVC race ways over the wiring.

Take the necessary care to avoid the crushing of cable when cover the race ways.

10 Make the "U" loops of wires in the hinged doors. Bunch and tie the cable in the doors.

11 Fix the wire clips at suitable places to hold the cables in the panel door.

'U' loop should not disturb the movement and closing of the panel door.

12 Connect the incoming and out going terminals as per diagram and terminal details.

Use the grommets to avoid the strain in the cables.

13 Earth the panel, door, control devices.

14 Measure the insulation resistance of the panel.

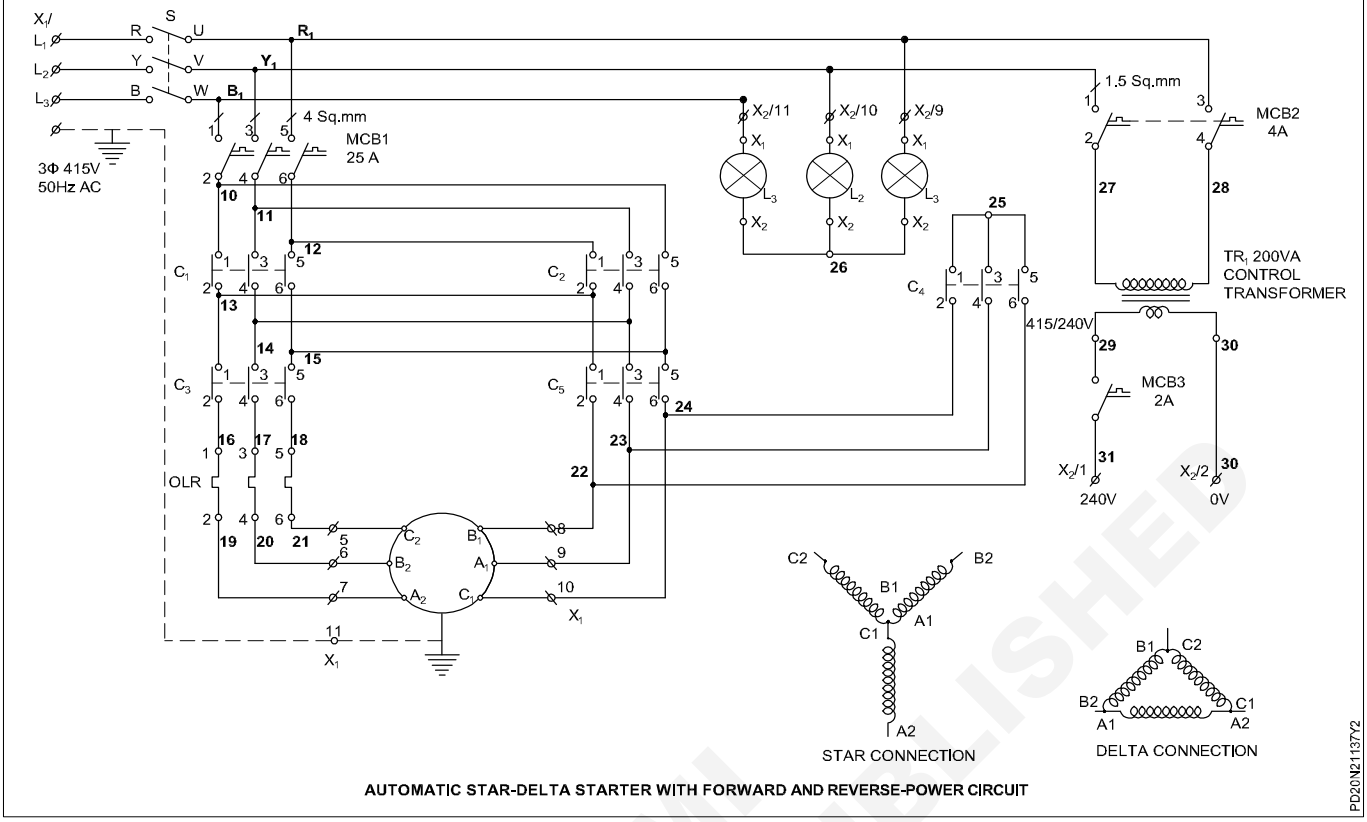
If the IR value is less than 1 Meg ohm, take suitable remedial action.

15 Set the OLR in accordance with the full load current of motor.

16 Connect the panel with motor and test the auto star delta starter with change of direction of rotation.

17 Show the control panel working to your instructor and get it approved.

Fig 2



AUTOMATIC STAR-DELTA STARTER WITH FORWARD AND REVERSE-POWER CIRCUIT

Indentify out door and indoor switch gear

Objectives: At the end of this exercise you shall be able to
- **visit substations and identify out door and indoor switch gear**

Requirements

Materials

• A4 Paper	- 1 No.	• Eraser	- 1 No.
• Pencil HB	- 1 No.	• Scale	- 1 No.
		• Manual for switch gears	- 1 copy each.

Instructor may take trainees to substations to identify outdoor and indoor switch gear.

PROCEDURE

Identifying outdoor switchgear involves several steps:

Location: Locate the switchgear outdoors, often in fenced enclosures or cabinets.

Visual Inspection: Check for a sturdy, weatherproof enclosure housing various electrical components like circuit breakers, disconnect switches, etc.

Labels and Markings: Look for labels or markings indicating its purpose, voltage ratings, manufacturer details, and any warnings or safety information.

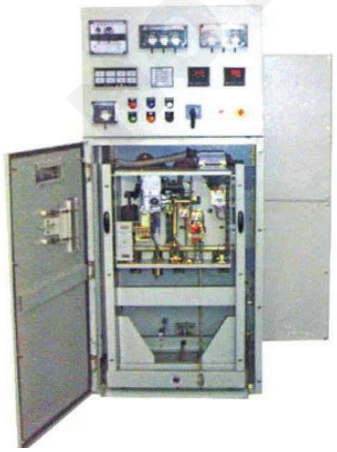
Components: Identify key components like circuit breakers, fuses, relays, and meters.

Safety Precautions: Ensure proper safety protocols are followed, such as wearing appropriate gear and avoiding contact with live components.

Documentation: Refer to manuals or documentation available onsite for further details about the switchgear's specifications and operation.

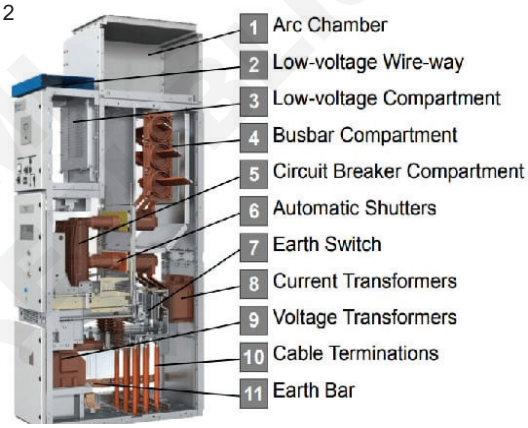
Consultation: If unsure or for detailed identification, seek guidance from a qualified electrician or someone familiar with the specific switchgear type.

Fig 1



Constructional parts of MV switch gear

Fig 2



Identifying indoor switchgear involves several steps:

1 **Visual Inspection:** Look for a metal enclosure, often larger than a circuit breaker panel, housing various switches, breakers, and electrical components.

2 **Labeling:** Check for labels or nameplates indicating voltage ratings, current capacity, manufacturer details, and other specifications.

3 **Components:** Observe the equipment inside, such as circuit breakers, busbars, disconnect switches, and relays, to differentiate it from other electrical devices.

4 **Size and Configuration:** Note the size and arrangement of the switchgear; it's typically larger and more robust than regular electrical panels.

5 **Location:** Indoor switchgear is often found in dedicated rooms, substations, or areas with controlled access due to its high-voltage capacity.

6 **Consultation:** If unsure, refer to manuals, electrical experts, or equipment documentation for further identification and understanding of the switchgear.

Fig 3

Indentify power and distribution transformers

Objectives: At the end of this exercise you shall be able to
- **identify power and distribution transformers.**

Requirements

Tool/Equipment/Material

• A4 Paper	- 3 Nos.	• Eraser	- 1 No.
• Pencil	- 1 No.	• Scale - 300mm	- 1 No.

The instructor may take the trainees to the nearest power station/transmission substation, and distribution substation and show power transformer and distribution transformer.

PROCEDURE

Identifying a power transformer involves a few steps:

Location: Locate the power supply or distribution area in a facility or on the grid.

Appearance: Look for a large, boxy metallic structure often with cooling fins, typically on a platform or elevated area.

Labeling: Check for any labels or tags indicating it's a transformer, including voltage ratings, manufacturer, or serial numbers.

Connections: Identify high-voltage lines entering and lower-voltage lines exiting the transformer.

Size and Equipment: Transformers are generally substantial in size and may be accompanied by associated equipment like circuit breakers or switches.

Remember, approaching or interacting with transformers can be dangerous, so it's essential to exercise caution and follow safety protocols.

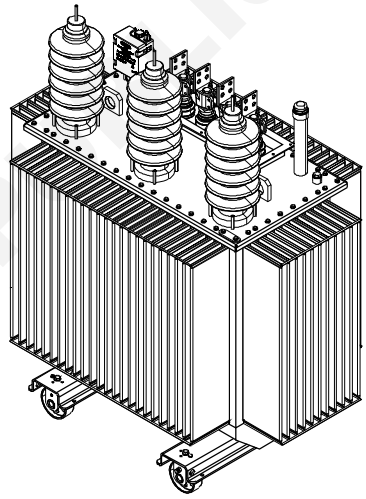
steps to identify a distribution transformer:

Physical Examination: Look for a medium-sized, box-like structure often mounted on a concrete pad or a pole. It usually has cooling fins or radiators for heat dissipation.

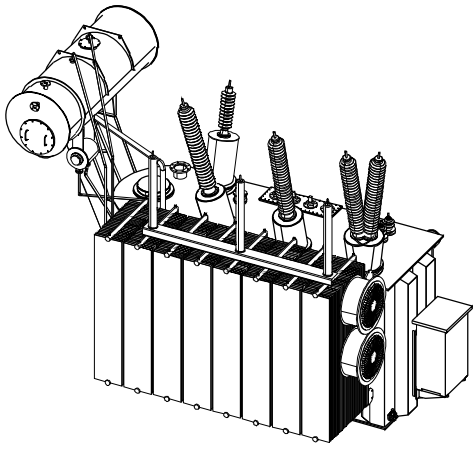
Labeling: Check for identification plates or labels on the transformer casing. They typically display information such as voltage ratings, kVA rating, manufacturer details, and serial numbers.

Voltage Ratings: Note the primary and secondary voltage ratings specified on the nameplate. Distribution transformers step down high-voltage electricity from the grid to lower voltages suitable for households or commercial use.

Fig 1



DISTRIBUTION TRANSFORMER



POWER TRANSFORMER

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Connections: Observe the incoming and outgoing cables or wires. The high-voltage lines connect to the primary side, while the lower voltage lines connect to the secondary side.

Size and Capacity: Assess the physical size of the transformer. Distribution transformers are typically smaller than power transformers and are designed for lower capacity, often ranging from a few kVA to a few hundred kVA.

Location: Distribution transformers are commonly found in residential areas, mounted on poles or placed in transformer vaults near buildings to supply electricity locally.

Remember, safety is crucial when identifying transformers. Avoid touching any part of the equipment and stay clear of high-voltage areas unless you're a trained professional.

Visit to power and motor control centre and identify various equipments

Objectives: At the end of this exercise you shall be able to
- **visit nearest power and motor control centre with instructor**
- **identify equipments used in pmcc**
- **prepare list of equipments with their functions.**

Requirements

Material

• Pew/Panel	- 1 No.
• A4 Paper	- 3 Nos.

Power and Motor control unit

Power and motor control units consist of various components that play essential roles in controlling and managing electrical power and motor operations. Some of the key components used in these units incluse.

1 **Circuit Breakers:** These devices protect the electrical system from overloads and short circuits by interrupting the flow of current when necessary.

2 **Contactors:** Contactor relays are used to control the operation of motors by providing a means to switch the motor on and off remotely.

3 **Motor starters:** Motor starters combine contactors with overload protection, allowing for safe and controlled motor operation.

4 **Relays:** Relays are used to control high-current circuits using low - current control signals. They help automate processes and protect against overcurrent situations.

5 **Fuses:** Fuses provide protection against overcurrent conditions by melting when current exceeds their rated value, breaking the circuit and preventing damage to equipment.

6 **Switches:** Various types of switches are used for manual control, such as disconnect switches, selector, switches, and emergency stop switches.

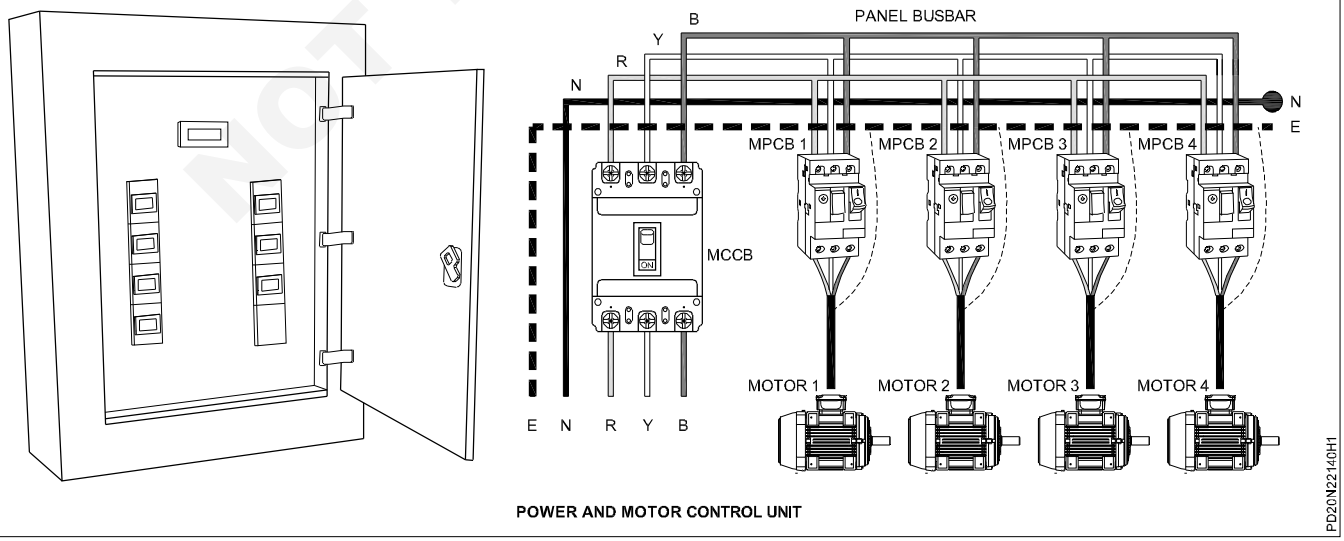
7 **Variable Frequency Drives (VFDs):** VFDs control the speed and torque of electric motors by adjusting the frequency and voltage supplied to the motor.

8 **Power Transformers:** These devices convert voltage levels to match the requirements of different components in the system.

9 **Motor Protection Devices:** These include thermal overload relays, motor temperature sensor, and current monitoring devices to protect motors from overheating and other issues.

10 **Control Panels:** Control panels house the various components and provide a user interface for monitoring and controlling the electrical system.

Fig 1

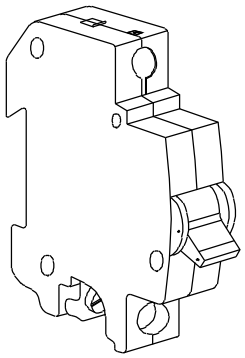


POWER AND MOTOR CONTROL UNIT

11 **PCLs (Programmable Logic Controllers):** PCLs are used for automation and control of complex processes, providing advanced programming capabilities.

12 **Sensors:** Sensors such as proximity sensors, temperature sensors, and speed sensors provide feedback to the control system for accurate monitoring and control.

Fig 2



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13 **Motor control centres (MCCs):** MCCs are assemblies that house motor starters, circuit breakers, and other control equipment for multiple motors in one centralized location.

14 **Busbars:** Busbars distribute power within the control unit efficiently and are made of conductive materials.

These components work together to ensure the safe and efficient control of power distribution and motor operations in various industrial and commercial applications.

Fig 3

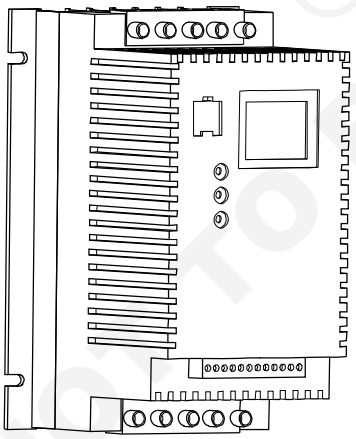

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Fig 4

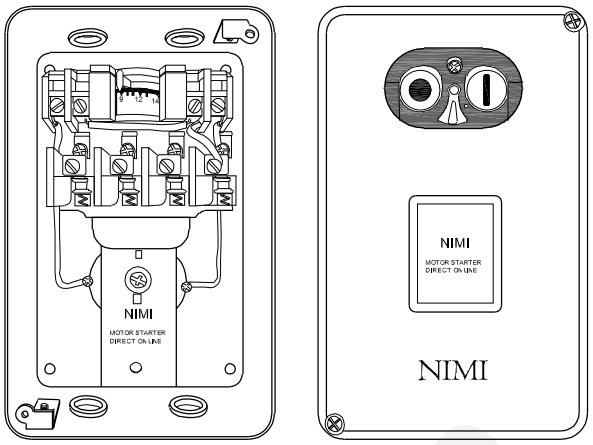

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Fig 5

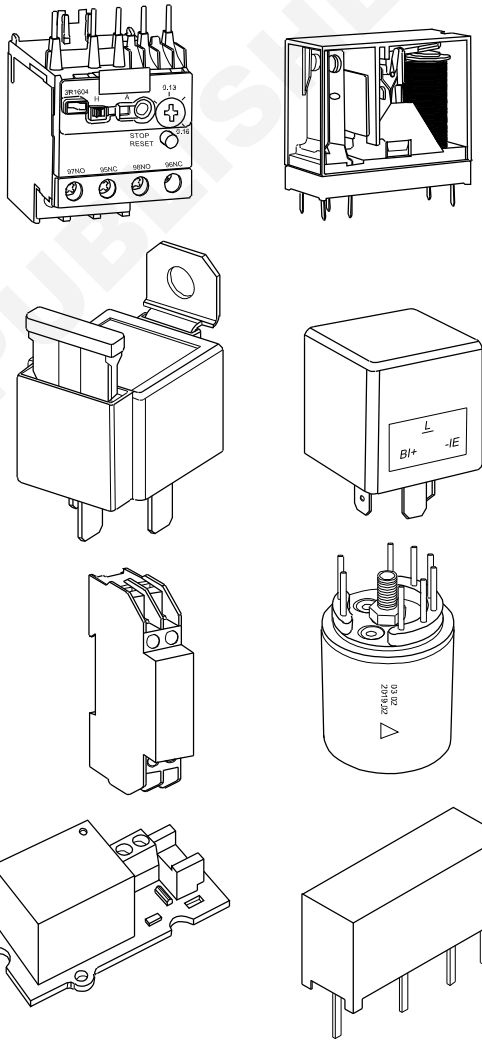

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Fig 6

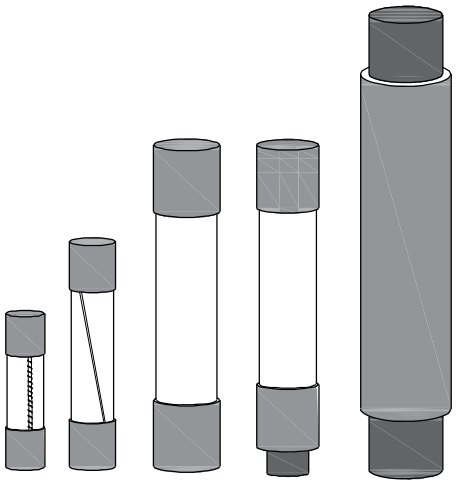

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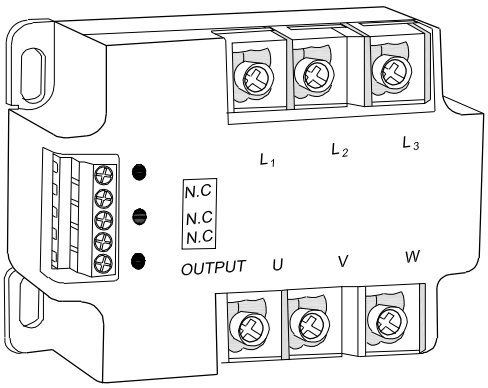
Fig 7



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Equipments used in PMCC you visited

Sl.No	Name of Equipment	Specifications	Function

Practice Live - dead - Live test in Electrical Panel (HV/LV)

Objectives: At the end of this exercise you shall be able to
- **to understand Live - dead - live test in HV Electrical panel - HV**
- **to understand Live - dead - live test in LV Electrical panel.**

Requirements

Material

• Multimeter / voltage tester	- 1 No.	• HV line tester	- 1 No.
• PPE (Personal protective Equipments)	- 1 Sets for each trainee.	• LT line tester	- 1 No.

1 Identify the circuit or panel you want to work on and turn off its power at the main circuit breaker or switch.

2 Use a voltage tester or a multimeter to confirm that the circuit is indeed de-energized.Test a known live circuit first to ensure your tester is working correctly.

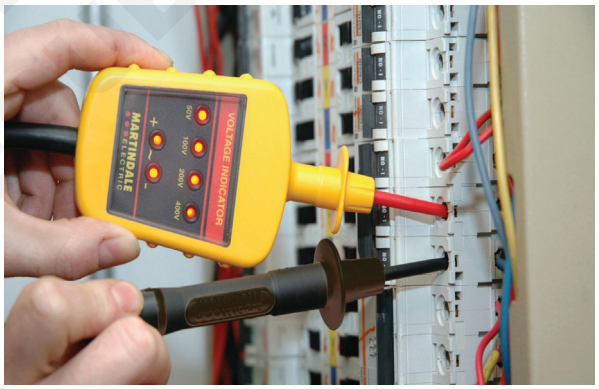
3 Once you have verified that the circuit is dead, turn it back on at the main circuit breaker.

4 Test the circuit again using the voltage tester or multimeter to make sure it is live.

5 Finally, turn off the power at the main circuit breaker again to begin your work.

Remember, safety is paramount when working with electrical panels.Always use appropriate personal protective equipment (PPE), follow proper procedures, and consult a qualified electrician if youare unsure about any step.Working with electricity can be dangerous, so always take the neccessary precautions to protect yourself and others.

Fig 1



Draw layout of thermal power plant and identify function of different layout element

Objectives: At the end of this exercise you shall be able to
- **visit the thermal power plant and identify the various stages in the plant**
- **interpret the function of each stage of thermal power plant**
- **prepare and draw the schematic diagram of thermal power plant.**

Requirements

Materials

• Drawing sheet	- 1 No.	• Eraser	- 1 No.
• Pencil (HB)	- 1 No.	• Scale -300mm	- 1 No.

PROCEDURE

Instructor may take the trainees to a nearest thermal power plant to visit the various stages of the power station and explain the functions of each stage.

Before entering the power station the instructor should explain to the trainees all the safety regulations pertaining to the power plant.

1 Visit the stages of a thermal power plant i.e.

a. Coal and ash handling arrangement

b. Steam generating plant

c. Steam turbine

d. Alternator

e. Feed water supply

f. Cooling arrangement

2 Identify the following constituents of a steam generating plant and write down their functions in Table 1.

Table 1

	Constituents	Type	Function
a	Boiler		
b	Super heater		
c	Economizer		
d	Air pre-heater		
e	Turbine		
f	Condenser		
g	Cooling tower		
h	Water treatment chamber		

3 Note down the details of the steam turbine and enter it in the diary.

4 Trace the various parts of alternator and note down the name plate details in Table 2.

Table 2

No.of phase _____ Single / three

Capacity _____ KVA / MVA

Speed _____ RPM

Output voltage _____ Volt

Current _____ Amp.

Frequency _____ Hz

Excitation current _____ Amp.

Sl.No_____

Year of Manufacturing_____

Model No _____

5 Draw the schematic diagram of thermal power station you visited in your record and get checked by your instructor.

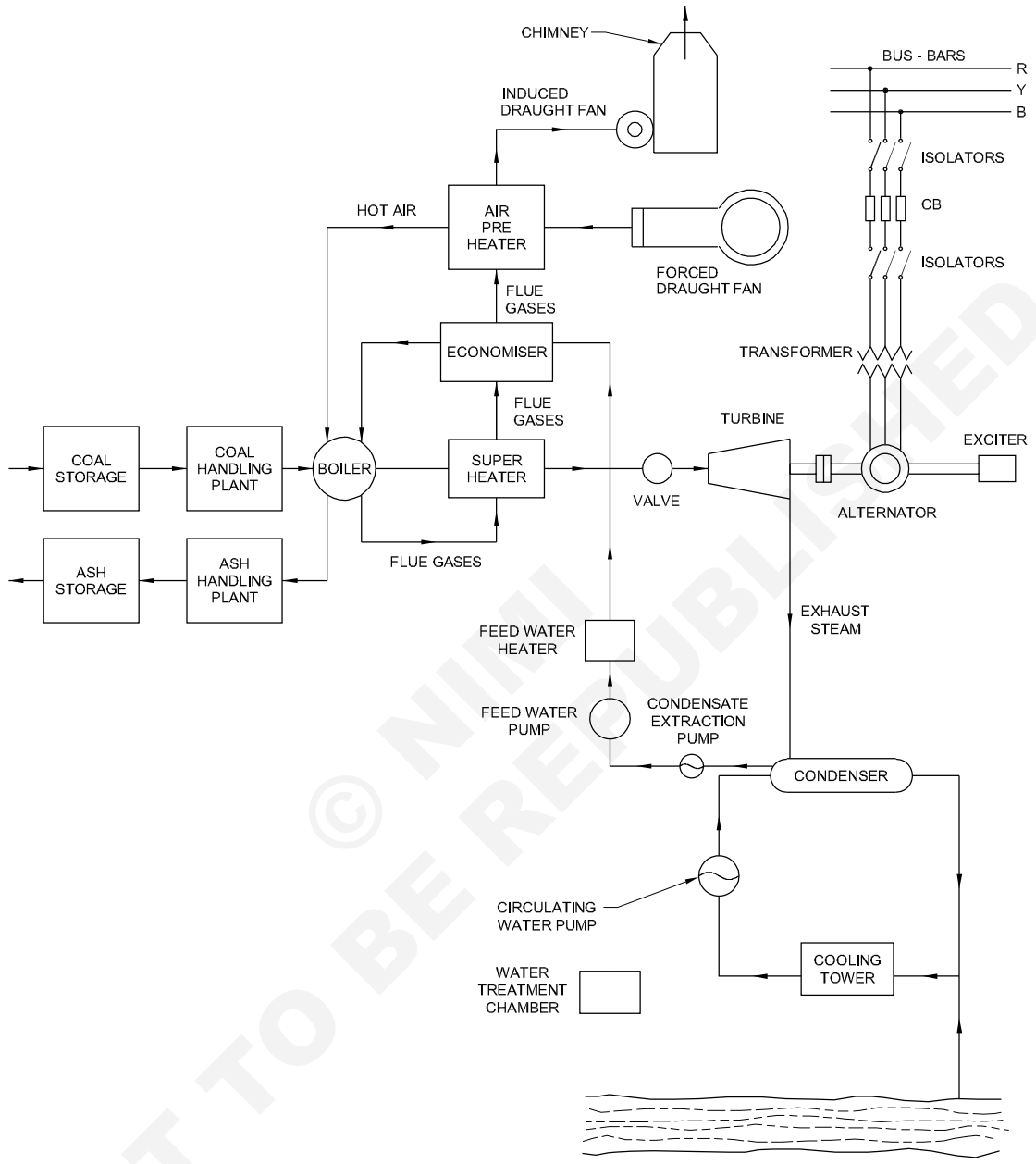
Fig 1 is the model schematic diagram of a thermal plant given for general guidance to trainees. The trainees have to prepare and draw the schematic diagram of the plant they visited.

6 Note down the main step-up transformer specification and the type of cooling arrangements.

7 Note down the voltage ranges transmitting from the power station.

Note down the boiler temperature range and method of temperature controlling and types of thermocouples used in boiler.

Fig 1



SCHEMATIC ARRANGEMENT OF STEAM POWER STATION

Draw layout of thermal power plant and identify function of different elements

Objectives: At the end of this exercise you shall be able to
- **visit the various stages of hydro-electric plant**
- **interpret the functions of each stage of hydro-electric plant**
- **prepare and draw the schematic diagram of hydro plant.**

Requirements

Materials

• Drawing sheet	- 1 No.	• Eraser	- 1 No.
• Pencil	- 1 No.	• Scale -300mm	- 1 No.

PROCEDURE

Instructor may take the trainees to a nearest hydro-electric power station to visit the various stages of the power station and explain the functions of each stage.

Before entering the power station the instructor should explain to the trainees all the safety regulations pertaining to the power plant.

1 Visit the stages of a hydro-electric power plant i.e.(1) Hydraulic structures (2) Water turbines (3) Electrical equipments.

2 Identify the following stages of a hydro-electric plant and write down their functions in Table 1.

Table 1

Constituents	Type	Function
a Dam		
b Spill ways		
c Head works		
d Surge tank		
e Pen stocks		
f Tail race		
g Draft tube		
h Turbine		

3 Note down the speed of the water turbine and other details and enter it in the diary.

4 Trace the various parts of alternator and note down the name plate details in Table 2.

5 Draw the schematic arrangement of a hydro-electric power station in your record and get checked by your instructor.

6 Note down the main step-up transformer specifications and the type of cooling arrangements.

7 Ensure that the cooling arrangement of power transformer, is water cooling or any other types.

8 Note the transmitting voltage range and the no. of transmission lines.

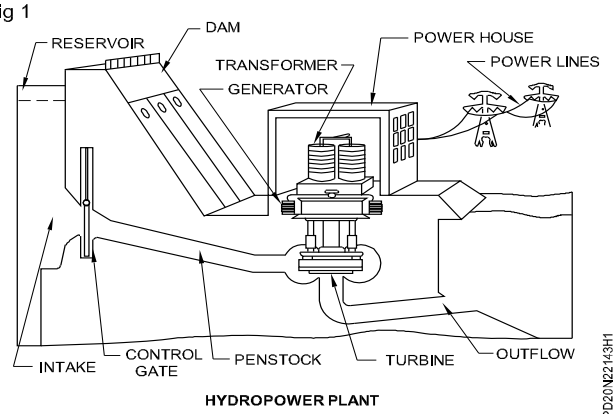
9 Note down the total installed capacity of the power station and maximum number of turbines working together at peak load hours.

10 Show your observation to your instructor.

Table 2

No.of phase _____ Single / three
Capacity _____ KVA / MVA
Speed _____ RPM
Output voltage _____ Volt
Current _____ Amp.
Frequency _____ Hz
Excitation current _____ Amp.
Sl.No_____
Year of Manufacturing_____
Model No _____

Fig 1



Draw single line diagram of transmission and distribution system

Objectives: At the end of this exercise you shall be able to
- **visit and trace the transmission and distribution system**
- **identify the equipments in sequential stages of transmission and distribution system**
- **prepare the layout and draw the single line diagram of the transmission and distribution system.**

Requirements

Tools/Equipment /Material

• Drawing sheet	- 1 No.	• Eraser	- 1 No.
• Pencil (HB)	- 1 No.	• Scale-300mm	- 1 No.

PROCEDURE

The instructor may take the trainees to the nearest transmission and distribution line system and explain the name of the equipment, their specification and function also instruct the trainees to follow the safety regulation while visiting the substation.

1 Visit the transmission and distribution line system and power plant.

2 Identify the sequential stages of transmission and distribution line system.

3 Trace and identify the various equipments like transformers, feeders, circuit breakers, Isolator, CT and PT etc, from the generation to the consumer points in sequence of transmission and distribution system.

4 Note down the earthing system. Note the different values of earth resistance displayed in the earth pit. Note down which equipment and installation requires the least earth resistance value and irregular value. Identify the hollow conductors used for connection between feeders.

5 Note down their details in Table 1 (Name, Specification and functions) for transmission system and Table 2 for distribution system.

Table 1

Transmission system

Sl.No	Name of the equipment	Specification	Function
1			
2			
3			
4			
5			
6			
7			
8			

6 Locate the places of equipments and draw the single line diagram of transmission and distribution system. Which you have visited.

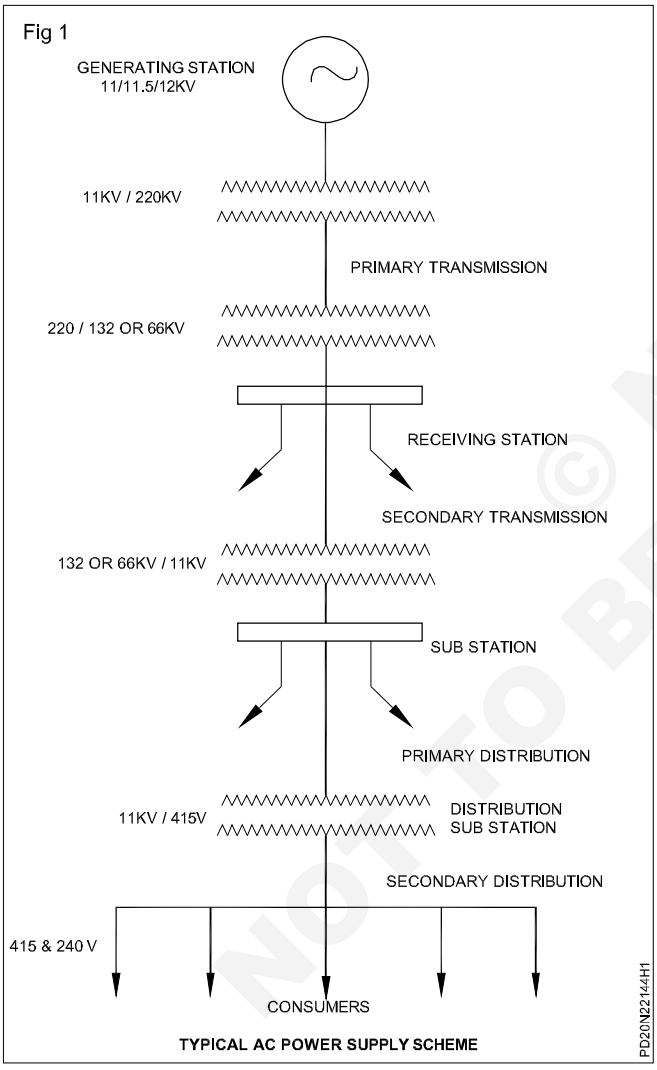
It may be like the diagram shown in Fig 1, 2. Refer related theory of this exercise also.

Table 2

Distribution line system

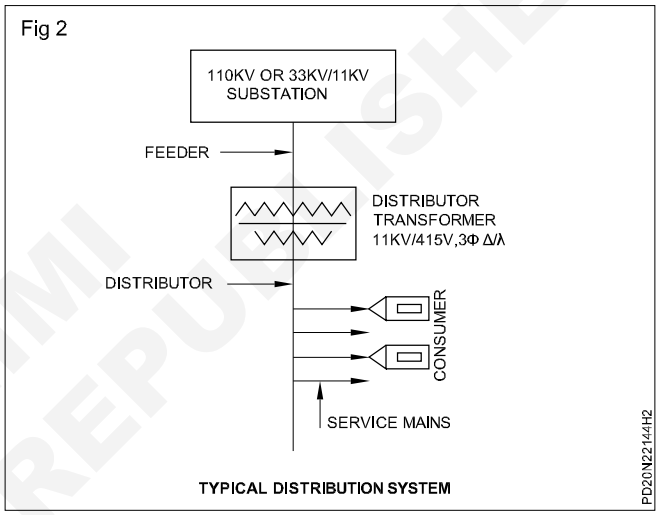
Sl.No	Name of the equipments	Specification	Function
1			
2			
3			
4			
5			
6			
7			
8			

Fig 1



TYPICAL AC POWER SUPPLY SCHEME

Fig 2



TYPICAL DISTRIBUTION SYSTEM

Identify various substation equipments, Isolators, overcurrent relay, earth fault relays, differential relay, REF relay, lightining arrestors, surge counter, wave trap, reactor, capacitor bank, circuit breakers-ACB, SF6 and VCB etc

Objectives: At the end of this exercise you shall be able to
- **visit and identify substation equipments**
- **prepare list of equipments seen in substation with their name plate details & specifications.**

Requirements

Tools/Equipment /Material

• A4 sheet paper	- 1 No.	• Eraser	- 1 No.
• Pen/pencil	- 1 No.	• Scale 300mm	- 1 No.

PROCEDURE

The instructor may take the trainees to the nearest substation and explain the name of the equipments, their specification and function. Also instruct the trainees to follow the safety regulation while visiting the substation.

1 **Isolator:** Isolator is a manually operated mechanical switch that isolates the faulty section of substation. It is used to separate faulty section for repair from a healthy section in order to avoid the occurrence of severe faults. It is also called disconnector or disconnecting switch.

2 **Overcurrent relay:** Overcurrent relay are electrical protection devices that are designed to open or trip a circuit when the current flowing through it exceeds a certain level, but on the higher side.

3 **Earth fault relay:** The Earth Fault Relay is an electrical protection device, designed to detect low earth leakage current and safeguard humans and electrical equipment from earth leakage or faults.

4 **Differential relay:** A differential relay is a protective relay used in power systems to detect and protect against abnormal current flow or faults.It operates by comparing the current entering a system with the current leaving it, commonly used to protect transformers, generators, motors and busbars.

5 **REF relay:** Restrict earth fault relay is a type of protection relay used in power system to detect and protect against earth faults within a specific zone of protection.It is commonly used to protect power transformers, generator, motors and other equipments where earth fault can occur.

6 **Lightning arrestor:** Lightning/surge arrestors are electrical devices used to protect electrical equipment and systems from the damaging effects of lightning, induced surges and voltage spikes. Lightning arrestors are typically installed at points where electrical lines or equipments enter building or other structures to divert excessive electrical energy away from sensitive equipment and into ground.

7 **Surge counters:** Are used to monitor the health of surge arrestors and protect against potentially damaging events which could lead to deterioration and ultimate overload.

8 **A wave trap:** Or line trap is a device that is used to block communication signals from passing through it and only allows power signals to pass through it.The wvae trap acts as a filtering cum protective device that filters the high-frequency signals to low-frequency signal and give protection against surge voltage.

9 **Reactors:** In a substation, shunt are connected normally between line and ground.The VAR absorbed by the reactor can be fixed or variable depending on the system requirement.The variation of VAR in the reactor can be achieved by using phase control thyristors or by DC magnetizing of the iron core.

10 **Capacitor banks:** Reduce the phase difference between the voltage and current.A capacitor bank is used for reactive power compensation and power factor correction in the power substations.Capacitor banks are mainly used to enhance the electrical supply quality and enhance the power systems efficiency.

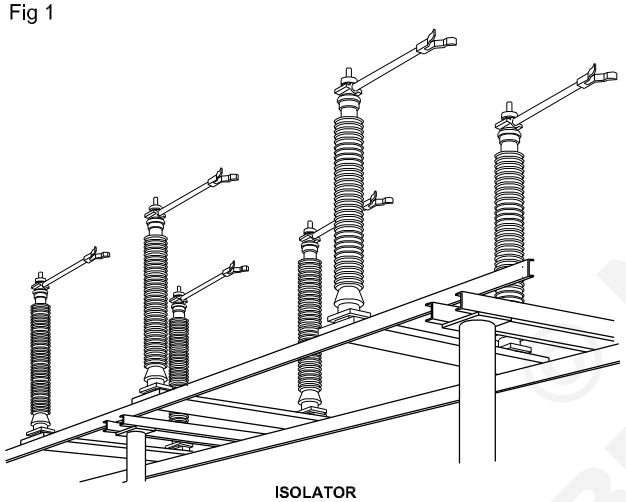
11 **Air blast circuit breaker:** Is a type of circuit breaker where at high pressure the air blast is used for arc

extinction in the electrical circuit.The main principle behind it is that it has a fixed contact and a moving contact, where high pressure is applied for arc extinction in a circuit breaker.

12 **SF6 circuit breaker:** Is a sulfur hexafluoride circuit breaker in which sulfur hexafluoride is used as the arc extinguishing medium. The sulfur hexafluoride gas attracts free electrons.SF6 gas has excellent insulating, arc extinguishing and many other properties which are the greatest advantages of SF6 circuit breakers.The gas is non-inflammable and chemically stable.Their decomposition products are non-explosive and hence there is no risk of fire or explosion.

13 **VCB vacuum circuit breaker:** (VCB) is the type of circuit breaker which uses vacuum between the electrodes as the arc quenching medium.The vacuum circuit breakers are mainly used in medium voltage applications, where the supply voltage ranges from 11kV to 33 kV.

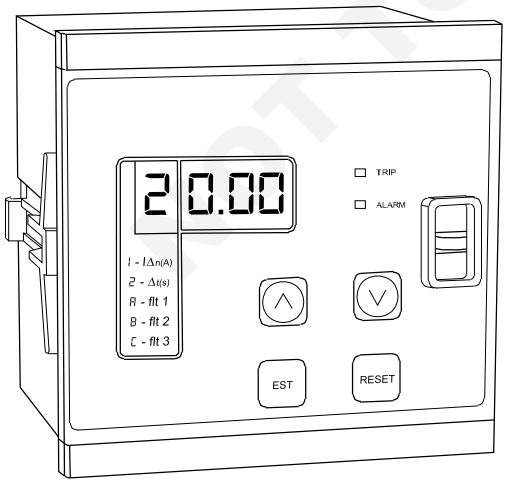
Fig 1



ISOLATOR

PD20N22145H1

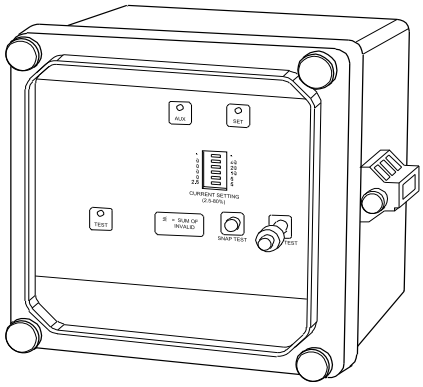
Fig 2



OVER CURRENT RELAY

PD20N22145H2

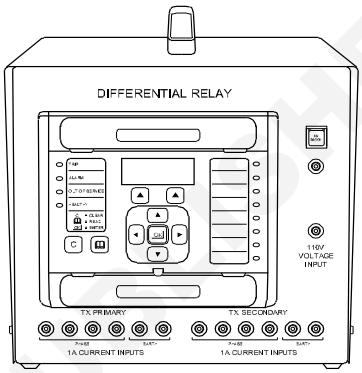
Fig 3



EARTH FAULT RELAY

PD20N22145H3

Fig 4



DIFFERENTIAL RELAY

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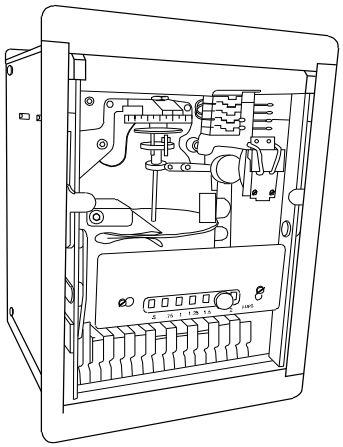
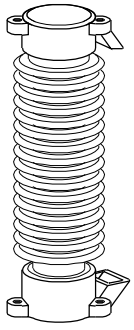
Fig 5



SINGLE POLE OVER CURRENT RELAY

PD20N22145H5

Fig 6

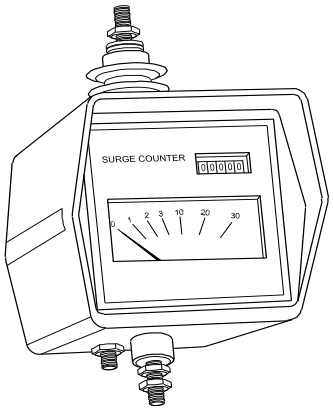


LIGHTING ARRESTER

PD20N22145H6

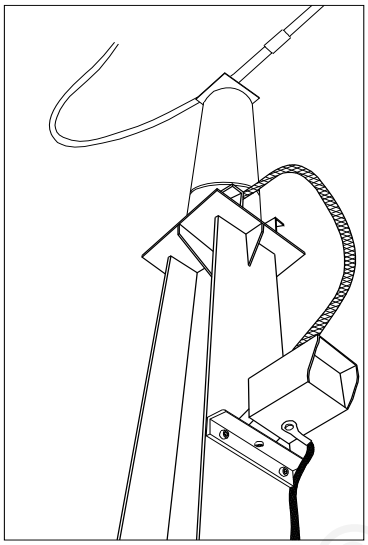
Fig 7

(a)



SURGE COUNTER

(b)



SURGE COUNTER WITH LA

PD20N22145H7

Fig 8

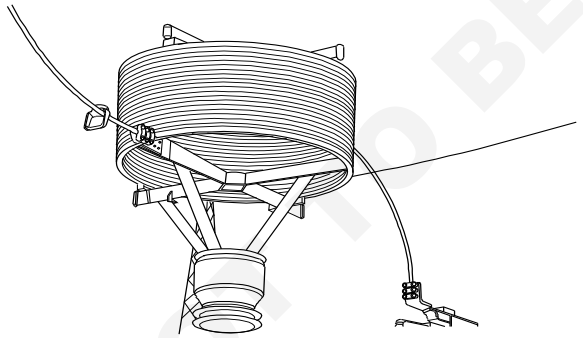


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Fig 9

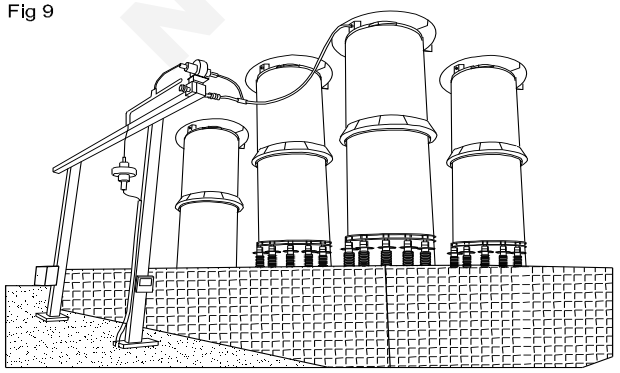

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Fig 10

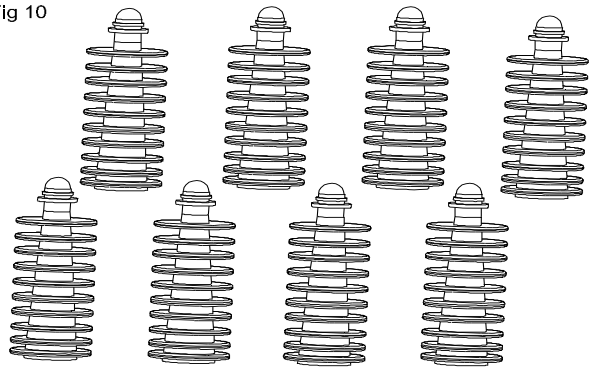

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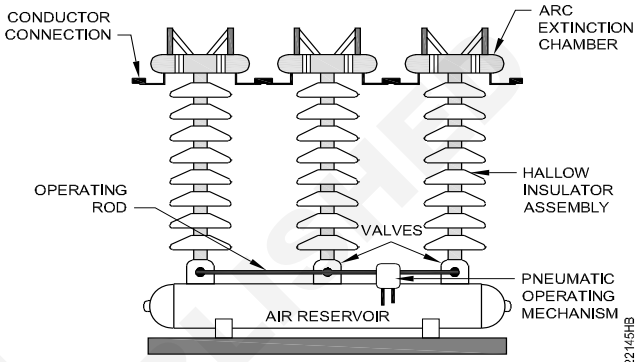
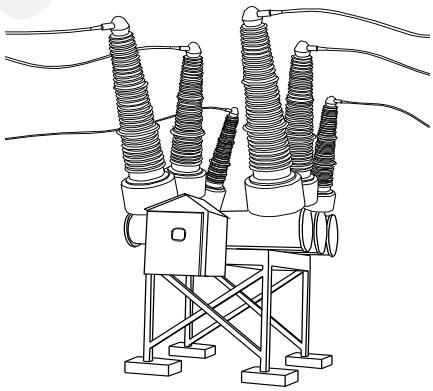
Fig 11



AIR BLAST CIRCUIT BREAKER (ABCB)

PD20N22145HB

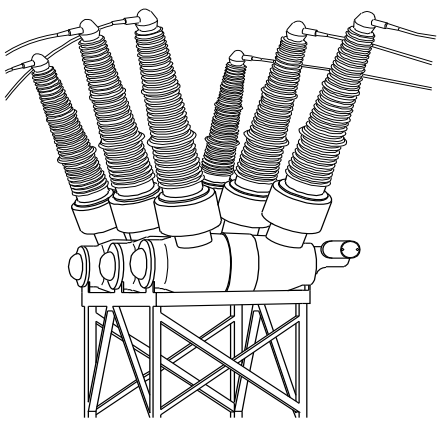
Fig 12



SF6 CIRCUIT BREAKER

PD20N22145HC

Fig 13



VACCUM CIRCUIT BREAKER

PD20N22145HD

Substation equipments

Objectives: At the end of this exercise you shall be able to
- **laying OPGW along with earth wire at the top of tower of HV line.**

Requirements

Material

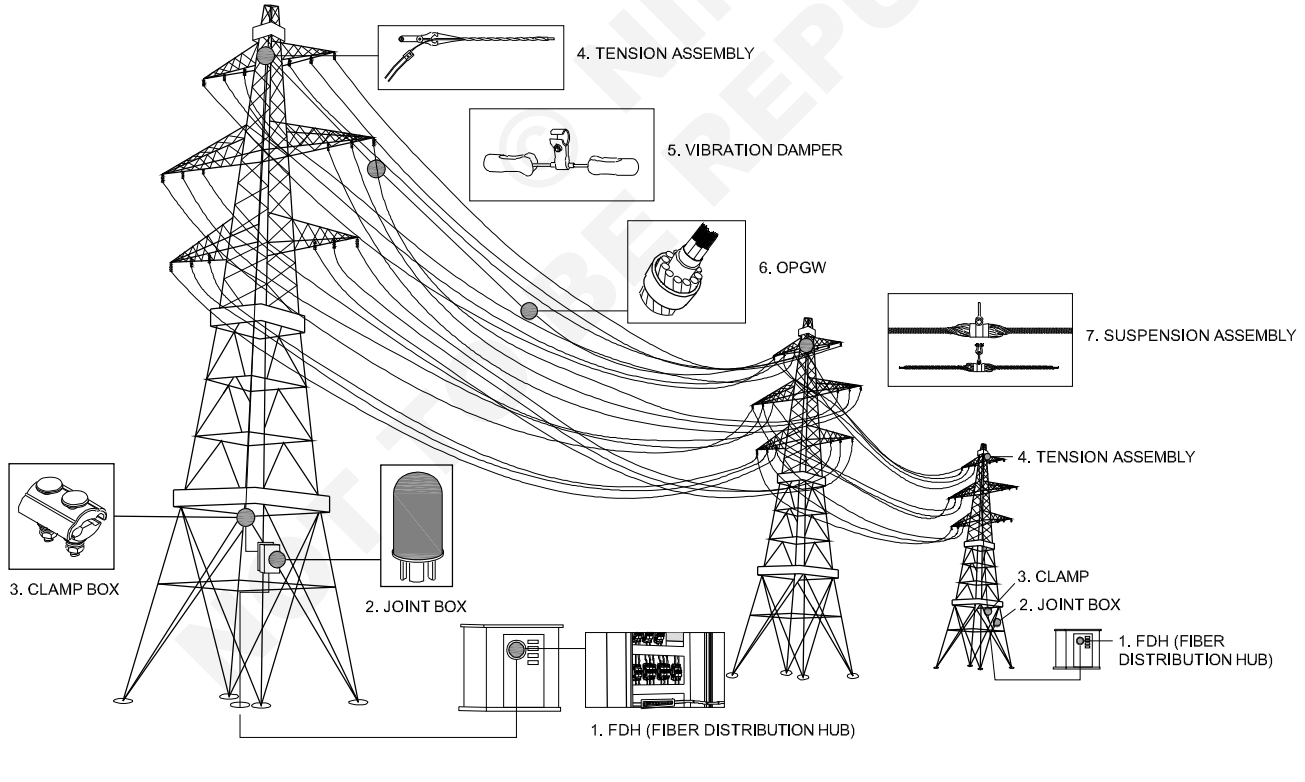
- Arrangements for video demonstration of laying OPGWalong with earth wire at the top of tower of HV line.

PROCEDURE

Instructor has to show video demonstration of laying OPGW along the earth wire at the top of tower of HV line

Understand that installing OPGW (Optical Ground wire) along with an earth wire at the top of high voltage transmission a tower is a common practice. The OPGW provides optical fiber communication capabilities, allowing for real time data transmission, while the earth wire functions to provide lightning protection and maintain the towers grounding system. This combination ensures both reliable power transmission and efficient communication for monitoring and control purposes.

Fig 1



Practice operation of isolators

Objectives: At the end of this exercise you shall be able to
- **close the isolator of Electrical circuit according proper procedure**
- **open the isolator of Electrical circuit according to proper procedure.**

Requirements

Tools/Equipment /Material

• PPE kit	- 1 No.	• pen/pencil	- 1 No.
• A4 paper	- 1 No.	• Non contact voltage tester	- 1 No.

The Instructor take trainees to the nearest substation with permission from Engineer incharge and explain procedures for closing and opening of Isolator.

PROCEDURE

1 **Preparation:** Ensure you have the necessary personal protective equipment(PPE) like gloves, goggles, and appropriate clothing. Make sure the isolator is in the "open" position and is not energized.

2 **Isolation:** Verify that the equipment or system to be worked on is de energised and licked out/tagged out according to safety procedures.

3 **Inspection:** Visually inspect the isolator for any signs of damage or abnormality. Make sure all connections and are in god condition.

4 **Access:** Gain access to the isolator's control panel or switchgear. Follow proper safety procedures for accessing electrical equipments.

5 **Operation:** Depending on the type isolator, you may need to operate a handle, lever or switch to close the isolator's contacts. This action isolates the electrical circuit or equipment from the power source.

6 **Verification:** Double-check that the isolator is indeed in the "closed" position and properly isolated. Use appropriate testing equipment to ensure there is no voltage present.

7 **Work permit:** obtain any necessary work permits or clearance to perform maintenance or repair the isolated equipment.

8 **Maintenance or repairs:** Perform the required maintenance or repairs on the isolated equipment.

9 **Reversal:** Once the work is complete reverse the isolation process by operating the isolator to open its contacts, reconnecting the equipment to the power source.

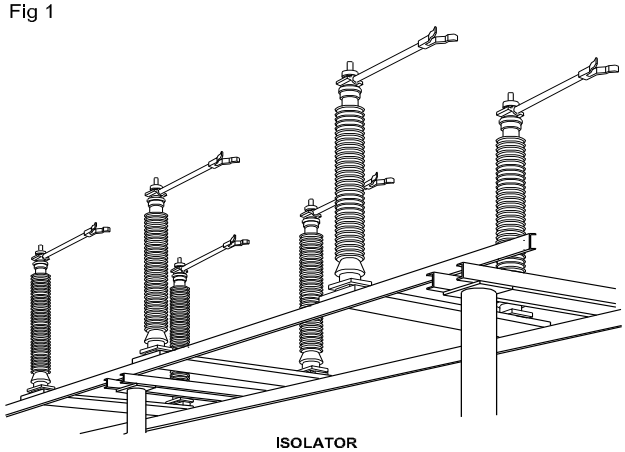
10 **Testing:** After re-energizing the equipment, conduct thorough testing to ensure everything is functioning correctly and safely.

Note:

Isolator shall be operated under no load condition because there no arc extinguish medium in Isolator.

Isolator shall be opened after opened after opened the CB and closed before closing CB.

Fig 1



ISOLATOR

PD20N22147H1

Identify different components of circuit breaker

Objectives: At the end of this exercise you shall be able to
- **identify the external parts of air circuit breaker**
- **identify the internal parts of air circuit breaker**
- **test the manual tripping of air circuit breaker.**

Requirements

Tools/Equipments

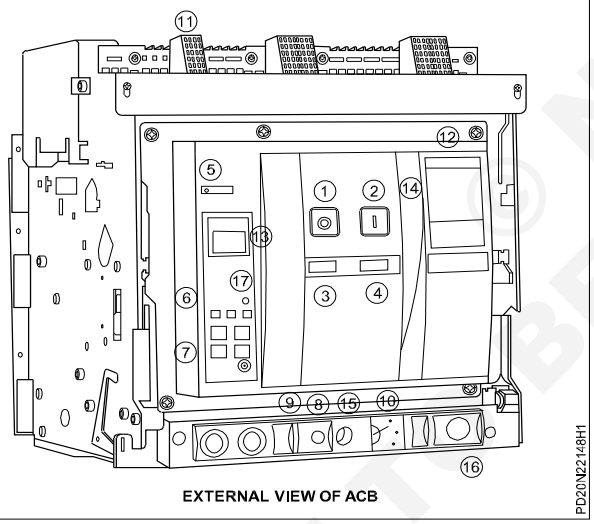
- Trainees tool kit - 1 No.
- Multimeter/ohm meter - 1 No.
- Air circuit breaker 3 phase 415V maximum capacity 400 KA with instruction manual - 1 No.

PROCEDURE

TASK 1 : **Identify the external parts and control switches of air circuit breaker**

1 Verify the specifications of air circuit breaker with instructions manual.

Fig 1



EXTERNAL VIEW OF ACB

Different makes of circuit breakers are available in the market. The air circuit breaker mentioned here is only a sample model for your guidance. The instructor may arrange the available model with necessary instructions if necessary.

2 Identify the label numbers of the external part mentioned in Fig 1.

3 Write the corresponding label numbers against the corresponding external parts names only given in Table 1.

Table 1

Name of external parts

Sl.No.	Parts label no	Name of the part
1	1	
2	2	
3	3	
4	5	
5	6	
6	7	
7	9	
8	13	
9	17	

4 Get it checked with your instructor.

— — — — — — — —

TASK 2: **Identify the internal parts of air circuit breaker**

1 Remove the front cover carefully.

Do not remove any permanent parts of the breaker.

2 Identify the main internal parts (Fig 2) fitted in the breaker and note down in Table 2.

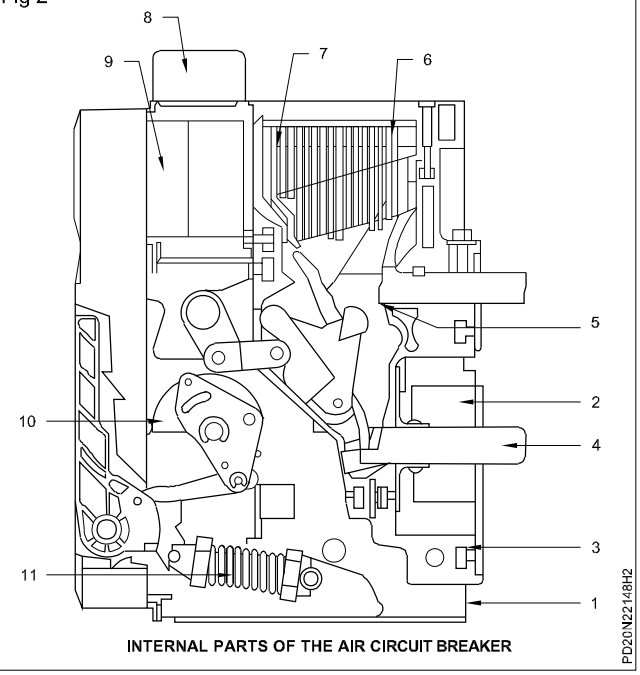
3 Locate the fixed main contact and movable main contacts.

4 Check the continuity of the contacts.

5 Locate the tripping coil terminals.

6 Remove the arcing chamber unit and test the arc chutes and diverters.

Fig 2



INTERNAL PARTS OF THE AIR CIRCUIT BREAKER

7 Locate the manual tripping lever to trip manually.

8 Connect the ACB to the main supply and switch ON.

9 Check the condition of indicating and tripping lamps.

10 Charge the breaker manually by operating handle.

11 Check the engaged main contact and confirm by checking its continuity.

12 Press the manual tripping switch and confirm its disengagement of the contacts.

13 Charge again the breaker and confirm the engagement of the main contacts.

14 Switch 'OFF' the AC mains, the arcing chamber and close the removed covers.

15 Submit the reports to your Instructor and get it approved.

Table 2

Name of internal parts

Sl. No	Parts no	Name of the part	Function
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			

Perform operation of circuit breakers in maintenance mode

Objectives: At the end of this exercise you shall be able to
- **connect relay and circuit breaker for test tripping**
- **set the current injection unit for tripping current**
- **set the tripping current for definite time lag (over current)**
- **set the current for extreme inverse characteristic (short circuit current).**

Requirements

Tools/Equipments

- Trainees tool kit - 1 No.
- Air circuit breaker 400 KA 415V with manual - 1 No.
- Over current relay with manual - 1 No.
- Current injection unit with manual - 1 No.

PROCEDURE

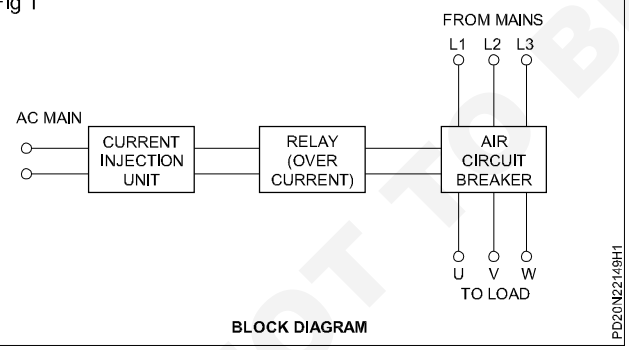
TASK 1: **Tripping of circuit breaker for definite time with set fault current**

This exercise is prepared to set the relay in definite time tripping in over current conditions and extreme inverse tripping in short circuit situations. This model relay is not having the facility of various tripping characteristics.

However short circuit current situation can be provided to trip the relay in short time by setting Time Multiplier Setting (TMS) to trip the relay instantly at high fault current situation.

1 Connect the relay, circuit breaker with the current injection unit by referring in block diagram. (Fig 1)

Fig 1



BLOCK DIAGRAM

2 Check all the connections as per the instruction manual.

3 Set the tap setting current in 1 amp and note down the multiplier, time in seconds in Table 1.

4 Set the TMS at position 1 marked in the dial.

5 Check the pick up current of the set value of tap setting current and note down values in table 1.

6 Set the fault current by selecting multiplier from the dial and note corresponding time in seconds and note the values in Table 1.

Now the fault current set value is 2 Amp and the relay should trip in the time as per the dial indication.

7 Switch 'ON' the current injection and note down the tripping indicated by the timer fitted on the current injection unit.

8 Reduce the time by setting TMS by 0.5.

Since the short circuit current cannot be generated practically the tripping time is reduced by taking the short circuit current is present now.

9 Ensure the rotating aluminium disc returns to its original position.

10 Switch ON the injection unit and note down the tripping time in seconds.

This time will be half time of the first reading.

11 Change the tap setting at 2 amps slot in the relay and repeat the steps 4 to 9.

12 Record the readings in the table and get it approved by your instructor.

Table 1

Test tripping of circuit breaker definite time charts

Sl. No	Tap setting current	TMS value	Time	Multiplier	Total fault current	Actual tripping current	Error in %
1							
2							
3							
4							

— — — — — — — —

TASK 2: **Tripping circuit breaker in extreme inverse characteristic condition**

1 Repeat the step 1 to 3 in Task 1.

2 Set the TMS at 0.2 position.

3 Set the tap setting plug into maximum current input on the dial.

4 Select the maximum multiplier value in the dial record the fault current (plug set value 'X' multiplier) and the tripping time in Table 2.

5 Check the pickup current for the tap set value.

6 Set the fault current in the current injector unit

7 Switch 'ON' and note down the actual tripping time in Table 2.

8 Try to some higher value of fault current and repeat the step 5 to 7. Record the values in Table 2.

Table 2

Extreme inverse charts

Sl. No	Tap setting current	TMS value	Time	Multiplier	Total fault	Actual tripping	Error in %
1							
2							
3							
4							

— — — — — — — —

Practice use of grounding rod and make visible earthing

Objectives: At the end of this exercise you shall be able to
- **make visible earthing of the use of grounding rod.**

Requirements

Tools/Equipments

• Earth electrode	- 1 No.	• Ground wire	- 1 No.
• Ground rod clamp	- 1 No.	• Plier	- 1 No.

PROCEDURE

- Select the suitable location for the grounding rod near the electrical system or equipment that requires grounding.
- Use a grounding rod made of copper or galvanized steel, typically 8 feet long.
- Drive the rod into the ground vertically until only a few inches are above the surface.
- Ensure good soil contact around the rod to enhance conductivity.

Visible Earthing

- Connect the grounding conductor (usually green or bare copper wire) from the electrical system or equipment to the grounding rod.

1 Choose a location near the electrical system or equipment that requires grounding.

2 Use a grounding rod made of copper or galvanized steel, typically 8 feet long.

3 Drive the rod into the ground vertically until only a few inches are above the surface.

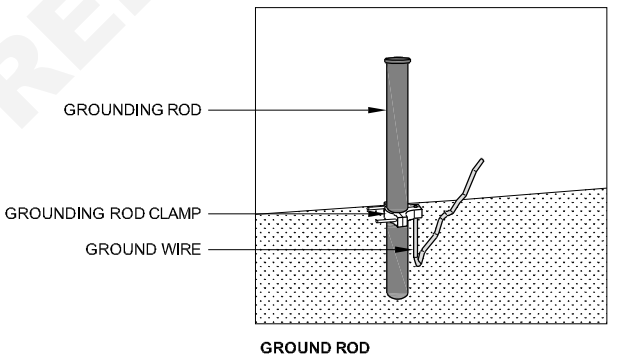
4 Ensure good soil contact around the rod to enhance conductivity.

5 Run the grounding wire along a visible path, such as along walls or metal conduits.

6 Avoid sharp bends or kinks in the wire to maintain its effectiveness.

7 At regular intervals, use clamps or straps to secure the grounding wire and maintain its position.(Fig 1)

Fig 1



Practice operation of circuit breakers, ACB, SF6 and VCB

Objectives: At the end of this exercise you shall be able to
- **operate air circuit breaker**
- **operate SF6 circuit breaker**
- **operate vacuum circuit breaker.**

Requirements

Tools/Equipments

• PPE kit	- 1 No.	• A4 paper	- 1 No.
		• Pen/pencil	- 1 No.

Operation of these circuit breakers should be performed by trained professional only and safety precautions must be followed. Instructor may take the trainees to the nearest substation where these type of ciruit breakers are used and make an opportunity to understand operation of different types of circuit breakers.

PROCEDURE

TASK 1: **Method of operating ACB**

1 Understand the manufacturer's manual and any safety guidelines for the specific ACB you are using Identify the part and controls of the ACB
2 Switch off power before operating the ACB
3 Make sure the ACB handle is in the "off" position before you start.
4 Slowly move the ACB handle to the "ON" position. This will connect the circuit and restore power.
5 Perform a test by closing and opening the ACB several times to ensure smooth operation.
6 If your ACB has an adjustable setting you can simulate an overload by setting it appropriately and then triggering the circuit breaker. This test helps verify its responsiveness.
7 Check for any indicator lights or meters that show the status of the ACB. This will help you understand if it's functioning correctly.
8 Note down the procedural steps for operating these circuit breakers.

— — — — — —

TASK 2: **Operating method of SF6 Circuit breakers**

1 Ensure that the circuit breaker is in the open position and the isolating contacts are open.
2 Make sure operator wear Electrical protective personal equipment
3 If the circuit breaker need to be closed, initiate the closing command. This may be done manually or automatically through control system. The closing spring drive the moving contact to close the circuit.
4 Opening the circuit breaker after the arc extinguished the spring drive the moving contact to open, Interrupting the current flow.

— — — — — —

TASK 3: **Operating method of Vacuum Circuit breaker**

1 Ensure that the circuit breaker is in safe and isolated condition. Make sure all relevant safety precautions are taken such as wearing appropriate personal protective equipment.
2 Check the VCB for any visible signs of damage, corrosion, or abnormalities. Ensure that the enclosure is clean and free from debris.
3 Ensure that the control panel is in the OFF position, Verify that any interlock of safety mechanism are properly engaged.
4 If the circuit breaker is in the open position, use control panel to initiate the closing operation. This will bring the contacts of the circuit breaker together.
5 Once the circuit breaker is closed, allow the short delay to let the contacts stabilize and before proceeding
6 When time to open the circuit, use control panel to initiate the opening operation. The contacts of the circuit breaker should separate
7 Maintain proper documentation of operation, including date, time, personal involved and any observations made during the process.

— — — — — —

Practice filling and evacuation of gas in SF-6 circuit breakers

Objectives: At the end of this exercise you shall be able to
- **do filling and evacuation of gas in SF-6 CB.**

Requirements

Tools/Equipments

- PPE kit - 1 No.
- Gas cylinder filled with SF6 gas - 1 No.
- Spanner 150 mm - 1 No.
- vaccum pump - 1 No.
- A4 paper - 4 Nos.
- pencil / pen - 1 No each.
- scale 300mm - 1 No.

As it is impracticable to get SF6 CB in your institute, it is necessary to take permission from engineer inchange of s/s where are SF6 CB used.Instructor may take the trainee to the nearest s/s and explain at the procedure to practice filling and excavation of gas in SF6 CB.

1 Visit transmission s/s with permission from Engineer-inchange, visit substation by where SF6. CB is existing.

2 CB are existing wear all PPE.

3 Ensure the circuit breaker is in the closed position and disconnected from the power source.

4 Check the pressure of the SF6 gas in the circuit breaker using a pressure gauge.

5 Connect a gas cylinder containing clean and dry SF6 gas to the circuit breaker's gas filling valve.

6 Open the gas cylinder valve slowly to allow the SF6 gas to flow into the circuit breaker Maintain the recommended filling pressure.

7 Monitor the pressure gauge to ensure proper filling. Close the gas cylinder valve once the desired pressure is reached.

8 Carefully disconnect the gas cylinder from the filling valve and close the valve.

9 Ensure the circuit breaker is in the closed position and disconnected from the power source.

10 Connect a vacuum pump to the circuit breaker's evacuation valve.

11 Open the evacuation valve and start the vacuum pump to remove any air and moisture from the circuit breaker.

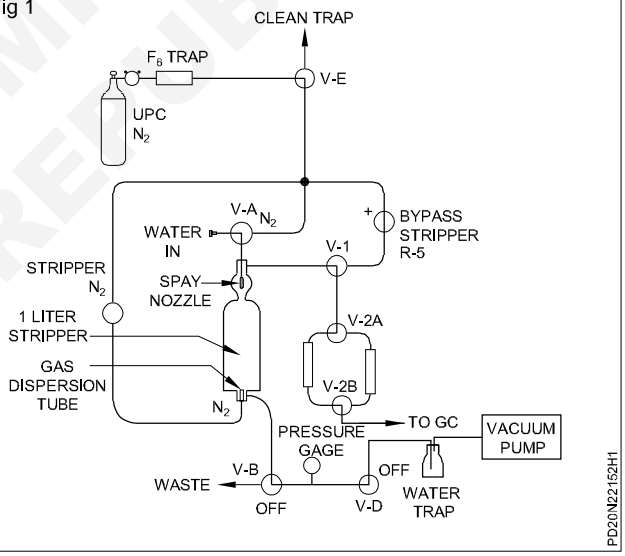
12 Monitor the pressure gauge to verify that the vacuum level is within the specified range.

13 Allow the vacuum pump to run for the recommended duration to ensure thorough evacuation.

14 Close the evacuation valve once the desired vacuum level is achieved.

15 Disconnect the vacuum pump from the evacuation valve.

Fig 1



Sl No	Time	Reading pressure gauge of SF6

Carryout timer test on circuit breaker

Objectives: At the end of this exercise you shall be able to
- **calculate the fault current in different percentage**
- **set up current in injector unit for different fault current**
- **set the pick up current of a 50% fault current**
- **set the time multiplier for time setting under various fault condition.**

Requirements

Tools/Equipments

- Trainees tool kit - 1 No.
- Over current relay with manual (used in previous Ex.No.4.7.203) - 1 No.
- Current injection unit with manual - 1 No.

PROCEDURE

TASK 1 : **Identify of pickup current and trip the relay for different fault current**

1 Identify the supply voltage required for operating over current relay to its tripping coil.

2 Identify the current input terminals of relay.

3 Identify the shorting pins of NC/NO relay contacts.

The current Injector unit is required to provide different fault current levels. The fault current settings is done in tap setting provided in the relay along with percentage of fault current with time.

4 Connect the tripping coil voltage and fault current connections from current injector to relay as per the manual instruction. Keep all the controls at zero position in current injector unit.

Some coils requires DC supply that can be taken from current injector unit.

5 Set the tap on relay for one amp. Calculate the multiplier from the dial and set the current in current injector unit. Record the values in Table 1.

Note : A sample reading is recorded in Table 1 on the tap setting at 1A; and multiplies value-2. Trip time displayed in dial an 10 seconds

Note : Select multiplier 2, so that the total fault current is 2 amp. ensure the time multiplier disc kept at position 1.

6 Note down the corresponding time displayed on the dial for multiplier 2.

The current injection unit have different makes and specifications . Energise the relay using manual supplied along with current injection unit.

7 Switch on the current injector unit ensure that relay is energised.

8 Increase slowly the current which is the input of relay to pickup.

Table 1

Sl. No.	TMS Position	Tap set current (A)	Multiplier value	Time in seconds	Total fault current	Pickup current	Actual trip time
1	1	0.5	2 x 0.5 = 1A	10 Sec.	1A	<1A	
2	1	1.0					
3	1	1.5					
4	1	2.0					

9 Increase the current slowly, the disc of relay start to move that is the pickup current. Note down the value in Table 1.

10 Change the tap set current to some other current value and repeat the step 5 to 9.

11 Change the tap set for other value and repeat the steps 6 to 10 and record the readings.

12 Try few more tap set values and check the pickup current.

TMS position should not be changed while doing the exercise.

— — — — — — — —

TASK 2 : **Reduce the tripping time by setting time multiplier setting**

1 Keep all the controls knobs at zero position.

2 Set the TMS disc at 0.5 position by rotating TMS disc fitted on the main spindle.

3 Repeat the steps 5 to 10 for the new TMS value of 0.5. Enter all the readings in Table 1.

Note : It may be noted that when TMS set for 0.5 the actual trip time reduced by 50% of the trip time actual in Task 1.

Table 1

Sl. No.	TMS Position	Tap set current (A)	Multiplier value	Time in seconds	Total fault current	Pickup current	Actual trip time
1	0.5	0.5 A	2 x 0.5 = 1A	10 Sec.	1A	<1A	
2	0.5	1.0 A					
3	0.5	1.5 A					
4	0.5	2 A					

— — — — — — — —

Carryout on repair and maintenance of circuit breaker

Objectives: At the end of this exercise you shall be able to
- **follow the shut down procedure**
- **refer to service and operating manuals of a given circuit breaker to identify the parts and their functions (R)**
- **refer to previous maintenance records for carrying out routine maintenance checks**
- **locate the faulty part and replace it**
- **follow the general maintenance procedure on the circuit breaker.**

Requirements

Tools/Instruments

- Insulated cutting pliers 150 mm - 1 No.
- Screwdriver 150 mm - 1 No.
- Heavy duty screwdriver 300 mm - 1 No.
- Neon tester 150 mm 600V - 1 No.
- D.E. spanner set of 9 Nos. 5 mm to 20 mm - 1 Set
- Box spanner set of 9 Nos. 5 mm to 20 mm - 1 Set
- Megger 500V - 1 No.
- Multimeter 20 kilo ohm/volt - 1 No.
- Cleaning brush round 2.5 cm - 1 No.
- Plumb bob with thread - 1 No.
- Spirit level 300 mm - 1 No.
- Flat file bastard 250 mm - 1 No.

Equipment/Machines

- Circuit breaker of higher voltage and current rating - 1 No.

Materials

- Rubber or cork gasket as specified and reqd.
- Sand paper Grade "0" - 1 Sheet
- Grease - 10 g.
- Flexible cable 14/0.2 - 5 mts.
- Dash pot oil of specific grade - 200 ml.
- Contact cleaner oil - CRC 2-26 - 1 bottle
- Electro tube - 25 g.

PROCEDURE

As it is impracticable to get a switch gear of high voltage and current rating in a vocational institute, it is recommended that the trouble shooting procedure is followed in a circuit breaker, having similar facilities like the rotor resistance starter used in a slip ring induction motor. However, the manufacturers instruction for the trouble-shooting should be followed for larger circuit breakers when the trainee is employed in an industry. The working steps given there are of a generalized nature and could be used with slight modification for any circuit breaker.

Caution: Before taking up the maintenance work on any circuit breaker which is in operation, it is utmost necessary to take permission from the engineer in-charge. He only decides whether alternative arrangement is required to maintain supply to the consumer or a shut down is to be effected.

Permission for shut down is given by the engineer in the approval forms. Follow all the instructions contained in the shut down form before taking up the maintenance work on the circuit breaker. The concerned control switch of the circuit breaker should be switched OFF and locked and caution boards should be displayed in the control panel. The key should be kept in the custody of the engineer in-charge. A caution board should also be displayed predominantly near the circuit breaker which is under maintenance.

1 Collect the service and operating manuals of the circuit breaker and read them carefully.

2 Collect the maintenance record sheet of the circuit breaker.

It is desirable that you read the service and operating manuals carefully and thoroughly before starting the actual maintenance work.

3 Note the name-plate details of the circuit breaker in Table 1.

Example of work permit and shut down

4 Switch 'OFF' the incoming and outgoing bus bars, and then disconnect the circuit breaker from the bus bars.

5 Follow the instructions contained in the service manual to open the top covers of the circuit breaker.

6 Identify the parts and compare with the service manual.

7 Identify and trace the tripping circuits.

8 Carefully inspect the parts for burnt smell, visible indication of burns, fittings and discolouring.

9 Interpolate your finding with the maintenance record sheet information to pin point the faulty part.

10 Identify the part number from the service manual and draw the parts from the stores.

11 Check the correctness of the part received from the stores and then replace the part in the circuit breaker.

General maintenance procedure

12 Check the mounting bolts/studs for correct tightness.

13 Check the verticality of the circuit breaker with the help of a plumb bob, and horizontality with the help of spirit level.

If necessary correct them by mounting bolts.

Table 1

Technical data of the circuit breaker

i	Type of the circuit breaker	.....
ii	Type designation	.....
iii	No. of phases/poles	.....
iv	Rated voltage	.....
v	Maximum voltage	.....
vi	Rated frequency	.....
vii	Rated current	.....
viii	Rated symmetrical breaking capacity	.....
ix	Rated making current	.....
x	Rated short time current	.....
xi	Quantity of oil per pole	.....
xii	One minute try withstand voltage	.....
xiii	Impulse withstand voltage	.....
xiv	Type of closing device	.....
xv	Trip free/fixed trip	.....
xvi	Weight of the oil	.....
xvii	Quantity of oil in litres	.....
xviii	Nett weight of the circuit breaker with oil in kg	.....
xix	Overall dimensions of OCB mounted on frame	.....
xx	Ambient temperature for which OCB is designed	.....
xxi	Auxiliary voltage for shunt trip coils	.....
xxii	Auxiliary voltage for under-voltage release	.....
xxiii	Auxiliary supply voltage for motor drive	.....

14 Check the stationary, fixed, arcing, intermediate and main contacts. Clean them with a steel wire brush or sandpaper grade '0' to remove any deposit due to oxidation. Figs 1 and 2 are given for your guidance.

If pittings are heavy, use a flat file to remove the pittings. If the surface area is reduced more than ten percent due to pittings it will be better to replace the contact points.

15 Clean the contact by using CTC solution.

16 Check the internal control wiring along with the given wiring diagram of the manual.

17 Use a continuity tester to test the continuity of each wire from point to point.

If the internal wiring cables are damaged replace them. Check for loose terminations and tighten them.

18 Measure the trip coil resistance and compare with the earlier measurement.

There should not be any change in coil resistance.

Fig 1

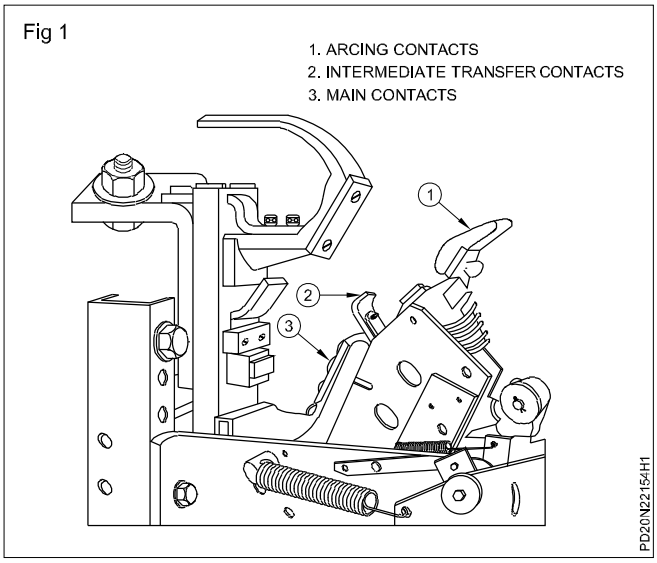
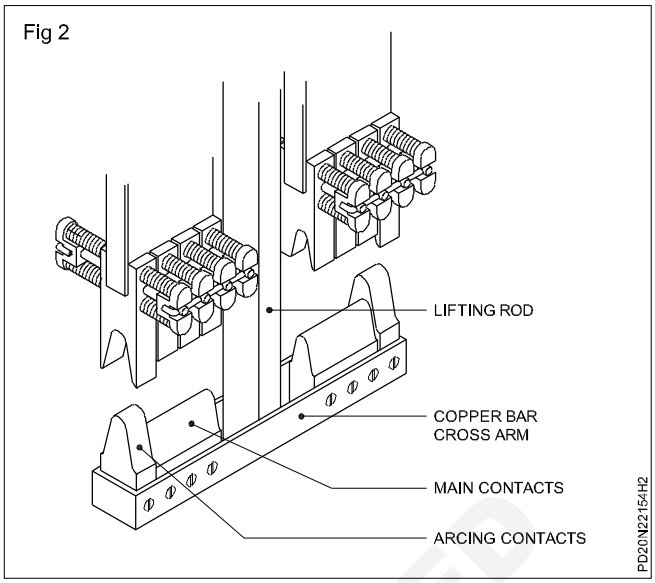


Fig 2



19 Check that the tripping rod and the armatures of the tripping releases, move freely without blocking or friction.

If the releases are found to be under friction clean the relevant part thoroughly.

20 Circuit breaker regular maintenance record sheet model given in Table 2.

Table 2

Maintenance record sheet for circuit breaker

Sl.No.	Date	Particulars	Complained by	Attended by	Description of fault	Particulars of replacement	Signature of the engineer in-charge
1							
2							
3							
4							
5							

— — — — — — — —

Identify lightening arrester in the Yard and practice replacement

Objectives: At the end of this exercise you shall be able to
- **identify lightening arrester**
- **replacing existing damaged lightning arrester with a new one.**

Requirements

Tools/Instruments

- Lightning arrester 9KV5K with manual - 1 No.
- Personal protective equipments - 1 Set.
- Adjustable spanner - 1 No.
- Cotton waste - as reqd.

Instructor may take trainees to the yard where lightning arrestors to be replaced.

PROCEDURE

1 Ensure that the power supply to the arrester is turned off and properly isolated. Use appropriate personal protective equipment (PPE) such as gloves, safety goggles, and insulated tools.

2 Identify the location of the existing lightning arrester. It's usually installed near the main electrical panel or at the point of entry of the power line into the building.

3 If the lightning arrester is connected to the electrical panel, turn off the circuit breaker that supplies power to it.

4 Use a voltage tester to confirm that there is no electricity flowing to the arrester before proceeding.

5 Carefully disconnect the wiring from the old lightning arrester. Take note of the wiring connections and configurations, so you can reconnect them correctly to the new arrester.

6 Unscrew and remove the old lightning arrester its mounting bracket.

7 If the new arrester isn't pre-assembled, follow the manufacturer's instructions to assemble it properly.

8 Securely mount the new lightning arrester to the same location as the old one using appropriate hardware.

9 Attach the wiring to the new arrester following the recorded configuration. Make sure all connections are tight and secure.

10 Once the connections are made, turn on the power to the arrester by flipping the circuit breaker back on.

11 If possible, perform a test to ensure that the new lightning arrester is functioning correctly. This might involve simulating a surge or contacting a professional for assistance.

12 After ensuring the functionality of the new arrester, check for any signs of leakage, sparking, or other issues. If everything looks fine, you're good to go.

Remember that the specific steps might vary based on the type of lightning arrester, its location, and your local electrical codes. If you have any doubts or concerns during the process, it's best to seek the help of a qualified electrician. Safety should always be a top.(Fig 1)

Fig 1

Practice reading of surge counter

Objectives: At the end of this exercise you shall be able to
- **take readings of sugar counter.**

Requirements

Tools/Instruments

• PPE kit	- 1 No.
• Paper	- 1 No.
• Pen	- 1 No.
• Scale 300 mm	- 1 No.

PROCEDURE

As Surgecounters are not available in your institute, Instructor may take the trainees to the nearest substation and explain the procedure to take readings of Surge counter.

1 Use PPE and with permission from engineer in charge visit substation bay where lighting arresters with Surge counters are installed.

2 Every time a transient voltage surge (e.g., from a lightning strike or other electrical disturbance) occurs, the surge counter registers the event and records it in its memory. The surge counter keeps track of the number of surges over time.

3 Many surge counters have a display that shows the accumulated surge count, allowing users to monitor the surge activity. Some models may also have a reset button to clear the count after reviewing the data or after maintenance activities. Maintenance and Risk Assessment: The data collected by the surge counter provides valuable insights into the frequency and intensity of transient voltage surges experienced by the electrical system or equipment. This information helps in assessing the effectiveness of the surge protection devices and aids in determining the maintenance requirements and the level of risk to the system.

4 Surge counters play an essential role in understanding the surges experienced by electrical systems, especially in areas prone to lightning strikes or other voltage transients By monitoring the surge count, users can make informed decisions regarding the need for additional surge protection measures, the performance of existing surge protection devices, and the overall reliability and safety of the electrical system.

5 Reading a surge counter involves checking and interpreting the data displayed by the surge counter device. Here's how you can practice reading a surge counter.

6 Find the surge counter device that is installed in parallel with a surge protection device (such as a lightning arrester) on the electrical system or equipment.

7 If the surge counter has a digital display, it will show a numerical value representing the accumulated surge count.

Some surge counters might also display additional information such as date and time of the last surge event or other relevant data.

8 Take note of the displayed surge count value. This value represents the number of transient voltage surges that the surge counter has recorded since its last reset.

9 If you have access to previous surge count readings, compare the current surge count with the historical data to understand the surge activity over time.

10 Consider the context of the surge count. Is the surge count relatively low or high? Higher surge counts might indicate areas prone to lightning strikes or frequent voltage disturbances.

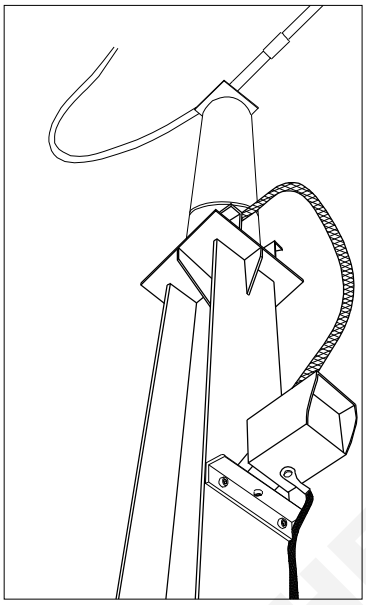
11 Evaluate the performance of surge protection devices based on the surge count data. If the surge count is significant, it might indicate that the surge protection devices are effectively diverting surges.

12 If the surge count is unexpectedly high or if there's a sudden increase in the surge count, it might be worth considering additional surge protection measures or maintenance activities to ensure the safety and reliability of the electrical system.

13 Some surge counters have a reset function. If you're instructed reset the surge counter after reading the data, do so following the manufacturer's guidelines.

Remember that surge counters provide valuable insights into the transient voltage surge activity experienced by the system or equipment. reading and the surge count can help you make informed decisions to improve surge protection, reduce risks, and enhance the overall performance of the electrical system.

Fig 1



SURGE COUNTER WITH LA

PD20N22156H1

Identify wave trap and LMU and practice replacement

Objectives: At the end of this exercise you shall be able to
- **identify wave trap**
- **identify LMU**
- **replacement of wave trip**
- **replacement of LMU.**

Requirements

Tools/Instruments

• PPE kit	- 1 No.	• Soft dry cloth	- 1 No.
• Tool kit	- 1 No.	• Wave trap for replacement	- 1 No.
		• LMU for replacement	- 1 No.

As wave trap is not available in you institute instructor may take trainees to the nearest substation to identify and practice replacement of the same.
Replacing a wave trap in a substation requires careful planning and execution to ensure safety and proper functionality.

PROCEDURE

TASK 1:

1 Obtain the necessary permits and approvals for the maintenance work.

Conduct a thorough risk assessment and establish safety protocols for the task.

Ensure the substation is de-energized and isolated from the power grid to avoid electrical hazards.

2 Locate the specific wave trap in the substation that needs replacement.

Identify its connection points and take note of any associated cables or connectors.

3 Procure the new wave trap of the correct make, model, and specifications as per substation requirements.

4 Gather the necessary tools and equipment for the replacement process.

Ensure all instruments and gear are in good working condition.

5 Carefully the old wave trap from its connections.

Follow the manufacturer's instructions and any substation-specific guidelines for removal.

6 Position the new wave trap correctly in the substation.

Connect it securely to the appropriate terminals and cables following the provided instructions.

7 Once the new wave trap is installed, conduct tests to ensure proper functionality.

Check for any potential issues or anomalies.

8 Once the replacement and testing are completed successfully, re-energize the substation safely.

Post-Replacement Checks:

Monitor the new wave trap's performance during the initial period to ensure it functions correctly.

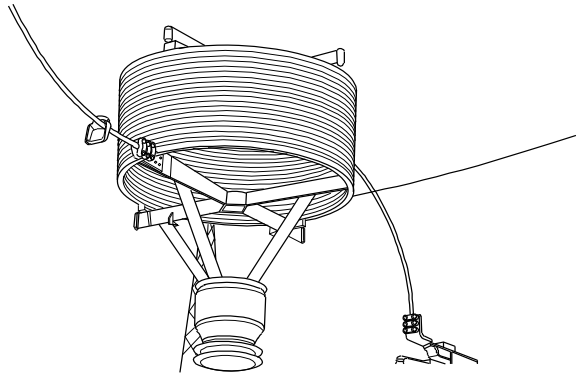
Conduct inspections as per the substation maintenance schedule.

9 Create detailed records of the replacement process, including any issues encountered and their resolutions.

Update substation documentation and maintenance logs accordingly.

Please note that the steps mentioned above are general guidelines. Specific procedures may vary based on the substation's design, equipment, and any manufacturer guidelines provided for the wave trap replacement. Always follow established safety procedures and consult with experienced personnel when performing such tasks.

Fig 1



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TASK 2:

Replacing a Line Matching Unit (LMU) in a substation involves several procedural steps to ensure safety and proper functioning. Here's a general outline of the process.

1 Obtain necessary permits and approvals for the maintenance work.

2 Gather all required tools, equipment, and replacement LMU.

3 Ensure proper personal protective equipment (PPE) for the maintenance team.

4 Coordinate with the control center to isolate the circuit and de-energize the relevant equipment.

5 Follow proper lockout/tagout procedures to isolate the circuit and equipment.

6 Use appropriate testing equipment to verify that the circuit is de-energized.

7 Safely remove any barriers or covers from the equipment housing the LMU.

8 Disconnect any cables, wires, and connections associated with the LMU.

9 Carefully unbolt or unclip the LMU from its mounting.

10 Installation of New LMU: Position the new LMU in the correct orientation and location.

11 Attach the LMU securely to its mounting using appropriate fasteners.

12 Reconnect all cables, wires, and connections following manufacturer guidelines.

13 Double-check the connections to ensure they are secure and properly tightened.

14 Perform continuity and insulation resistance tests on the LMU's connections.

15 Use appropriate testing equipment to check for any abnormal readings or faults.

16 Verify that the new LMU is compatible with the existing system.

17 Notify the control center that the replacement is complete and ready for re-energization.

18 Follow established procedures to restore power to the circuit gradually.

19 Monitor the system for any unexpected behavior or abnormalities as power is restored.

20 Functional Checks: Conduct functional tests to ensure the new LMU is working as intended.

21 Check for proper communication between the LMU and other control or monitoring devices.

22 Confirm that the LMU is providing the necessary line matching and impedance matching functions.

23 Document all steps taken during the replacement process. Update equipment records, maintenance logs, and any necessary documentation Note any deviations, observations, or issues encountered during the replacement.

24 Remove any tools, equipment, and debris from the work area. Ensure that the area is clean and safe for further operations.

25 Monitor the circuit and equipment for a period to ensure stable and proper operation.

26 Address any unexpected issues or abnormalities that arise.

Always remember that safety is paramount during any maintenance work in a substation.The procedures may vary based on the specific substation's design and the manufacturer's guidelines for the LMU.It's crucial to follow your organizations established procedures and consult with experienced personnel when performing such tasks.

Fig 2

Carryout maintenance of wave trap and LMU

Objectives: At the end of this exercise you shall be able to
- **do maintenance of wave trap**
- **maintenance of LMU.**

Requirements

Tools/Instruments

- Personal protective equipment - 1 Set.
- Soft dry cloth/Brush - 1 No.
- Spanner - 1 No.
- Screw driver - 1 No.
- Non - contact voltage tester - 1 No.
- Wave trap with manual - 1 No.
- LMU with manual - 1 No.

PROCEDURE

TASK 1: **Maintenance of wave trap**

1 Always follow safety procedures and wear appropriate personal protective equipment (PPE) when working with electrical equipment.

2 Visually inspect the wave trap for any signs of physical damage, such as cracks, rest, or loose connections.

3 Clean the wave trap's insulators and terminals using a soft, dry cloth or a brush to remove dust, dirt, or containments.

4 Check and tighten all connections to ensure proper electrical contact and avoid potential hotspots.

5 If the wave trap is oil-filled, conduct regular oil analysis to monitor its condition and detect any degradation.

6 Conduct functional tests to ensure the wave trap is operating correctly and responding as expected.

7 If the wave trap has adjustable settings, make sure they are calibrated correctly.

8 Maintain detailed records of maintenance activites, test results, and any abnormalities found.

Fig 1

— — — — — — —

TASK 2: **Maintenance of LMU**

1 Gather all necessary tools and equipment for maintenance, a such as safety gear, manuals, spare parts, and any specialized tools required.

2 Safely shut down the line matching unit according to established procedures. Ensure that all power sources are disconnected, and isolate the unit from any energy sources to prevent accidental startup.

3 Visually inspect the unit for any signs of wear, damage, or leaks. Check the surrounding area for any hazards or potential issues that could affect maintenance.

4 Clean the unit thoroughly, removing any debris, dirt, or residue that may have accumulated. Use appropriate cleaning agents and tools to avoid damaging sensitive components.

5 Inspect individual components such as valves, connectors, sensors, and belts for signs of wear, corrosion, or malfunction. Replace any damaged or worn-out parts with approved replacements.

6 If applicable, lubricate moving parts according to manufacturer recommendations. Ensure proper lubricants are used and follow the recommended intervals.

7 Check the alignment of the unit and its components to ensure proper functioning. Calibrate any sensors or measurement devices according to the manufacturer's guidelines.

8 Inspect electrical connections, wires, and control panels. Tighten loose connections and replace faulty wiring or components as needed.

9 Conduct thorough testing of the unit after maintenance. This may involve simulated operation, functional tests, and performance checks to ensure that the unit operates as expected.

10 Keep detailed records of the maintenance activities performed, including any parts replaced, adjustments made, and testing outcomes. This documentation can help track the unit's history and aid in future maintenance.

11 Before restarting the unit, perform safety checks to ensure that all guards, covers, and safety mechanisms are properly in place and functional.

12 Gradually start up the unit and monitor its operation closely, Look for any unusual noises, vibrations, or abnormal behaviors that might indicate lingering issues from the maintenance.

13 Perform a final inspection to confirm that the unit is operating as intended and that all maintenance tasks have been successfully completed.

14 If any issues are identified during the post-maintenance period, address them promptly. Monitor the unit's performance for a period after maintenance to ensure that it remains in optimal condition.

Remember, the specific steps and requirements may vary based on the type of line matching unit you're dealing with. Always follow the manufacturer's guidelines and any established maintenance procedures within your organization.

Fig 2

Verify terminals identify components and calculate transformation ratio of single phase transformers

Objectives: At the end of this exercise you shall be able to
- **read and interpret the details of the name-plate of single phase transformer**
- **identify H.T & L.T. winding**
- **determine transformation ratio (turns ratio) by the**
  - **voltmeter method**
  - **ammeter method.**

Requirements

Tools/Instruments

- VoltmeterM.I. 0 - 250/300V - 2 Nos.
- Ohmmeter (0 - 500 ohms) - 1 No.
- Ammeter M.I. type (0 - 10 Amp) - 1 No.
- Ammeter M.I. 100 mA - 1 No.
- Voltmeter M.C. 0-15V - 1 No.

Equipment/Machines

- D.C. supply 12 volts - 1 No.
- Single phase transformer 115/230 volts, 1KVA - 1 No.
- Auto-transformer (IP-240V) OP 0-270V, 5A - 1 No.

Materials

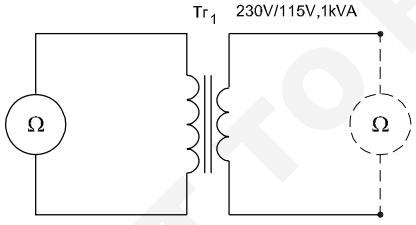
- Knife switch DPST 16A 250V - 1 No.
- Push-button 6A, 250V - 1 No.
- Connecting cables - as reqd.

PROCEDURE

TASK 1 : **Identify terminals**

1 Find out the corresponding terminals of two windings (H.T. & L.T) with ohmmeter as shown in Fig 1, by checking the continuity.

Fig 1



CIRCUIT FOR IDENTIFICATION OF TERMINALS OF SINGLE PHASE TRANSFORMER

2 Determine HT and LT winding by measuring resistances with the ohmmeter.

L.T. windings will have low resistance in the case of step down transformer.

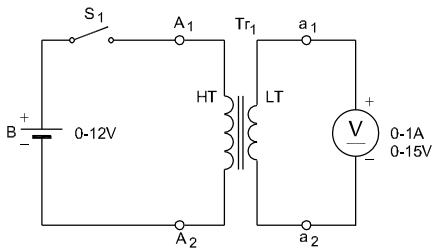
Record resistance of both pairs.

1st pair _____ ohms. This is HT/LT winding.

2nd pair _____ ohms This is HT/LT winding.

3 Connect DC supply to HT through push-button switch and connect the voltmeter to LT as shown in Fig 2.

Fig 2



NOTE:
INSTEAD OF THE BATTERY DC STABILIZED POWER SUPPLY CAN BE USED

CIRCUIT FOR IDENTIFICATION OF POLARITY OF TRANSFORMER

4 Mark HT terminals as A_1 and A_2. Mark at LT terminals as a_1 and a_2.

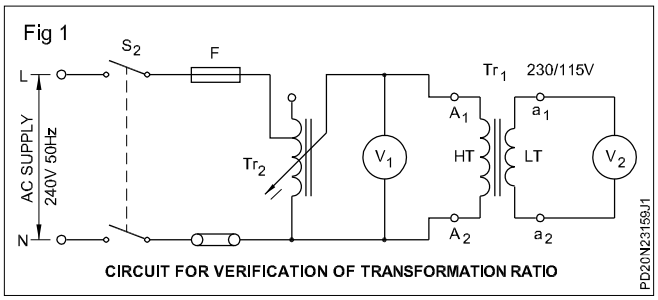
5 Press the push-button switch. Observe the deflection of the pointer of the voltmeter. If the pointer deflects in the right direction, retain the markings made on terminals.

6 Change the voltmeter connections made to LT terminals and change the marking made on the LT terminals if the deflection is in the reverse direction. Now press the push-button switch once again and observe that the voltmeter deflects in right direction.

TASK 2 : **Verification of transformation ratio (by voltmeter method)**

1 Connect the auto-transformer and the voltmeters to the transformer as shown in Fig 1. Check and set the auto-transformer at zero volt output position.

Fig 1



CIRCUIT FOR VERIFICATION OF TRANSFORMATION RATIO

2 Switch on 'S_2' and adjust the autotransformer to get the output voltage V_1 = 100 volts and read V_2 record the value in Table 1.

The output voltage of the auto-transformer should be adjusted to about 50% of the rating of the H.T. side.

3 Set the V_1 value for the values indicated in Table 1 and record the corresponding readings of V_2 in Table 1.

4 Calculate the transformation ratio from the measured V1 & V2 values.

Applying the formula -

Transformation ratio = $\frac{V_2}{V_1}$

Table 1

Sl. No.	V_1	V_2	Transformation ratio $K=V_2/V_1$
1	100 Volts		
2	125 Volts		
3	150 Volts		
4	200 Volts		
5	225 Volts		

5 Compare the calculated transformation ratio with the marking of name plate.

6 Transformation ratio calculated

from measurements =

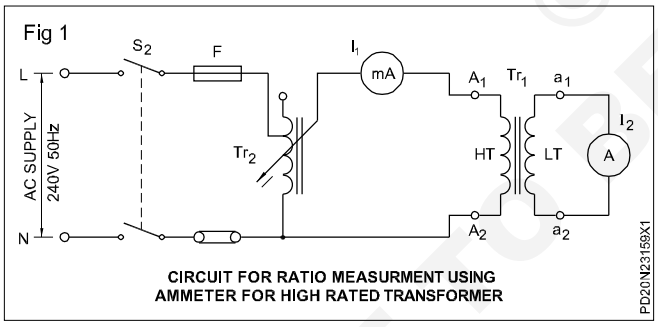
from markings =

— — — — —

TASK 3 : **Verification of transformation ratio (by ammeter method)**

1 Connect the auto-transformer output to the transformer H.T. winding through a milliammeter in the line as shown in Fig 1.

Fig 1



CIRCUIT FOR RATIO MEASURMENT USING AMMETER FOR HIGH RATED TRANSFORMER

The current in the H.T. winding should be kept low, but should be large enough to be measured accurately with a milliammeter.

2 Connect the L.T. winding to the ammeter. The ammeter should carry the rated current of L.T. side.

Use the current transformer and ammeter if the secondary rating is very high.

3 Increase the voltage to give the required current in H.T. winding.

4 Read the L.T. current. Record in Table 2.

5 Change the H.T. current to different values and record the corresponding L.T. current.

Table 2

Sl. No.	I1	I2	Transformation ratio K=I1/I2
1			
2			
3			
4			

6 Verify the transformation ratio with the markings on the name-plate and record your findings.

_____

_____

_____

_____

— — — — —

Determine voltage regulation of single phase transformer at different loads and power factors

Objectives: At the end of this exercise you shall be able to
- **connect the transformer with suitable instruments to measure load and power factor**
- **calculate the regulation of single phase transformer from the readings of instruments in primary and secondary side.**

Requirements

Tools/Instruments

- Ammeter M.I.-0 to 5A, 0 to 10A each - 1 No.
- Voltmeter M.I.-0 to 300 V, 0 to 150 V - 1 No. each
- P.F.meter 0.5 lag -1 - 0.5 lead 250 V rating - 1 No.

Equipment/Machines

- Induction motor with starter & loading
- arrangement 240V 50Hz 1 HP - 1 No.
- Auto-transformer Input 40V Output 0 to 270 V, 5 amps - 1 No.
- Single phase transformer 115/230V 1 kVA, 50 cycle air cooled - 1 No.
- Lamp bank 5 A, 250V - 1 No.

Materials

- Connecting cable - as reqd.
- 40 watts-tube light fitting - 10 Nos.
- DPST switch 250V 16A - 2 Nos.
- SPT switch 6 A - 2 Nos.

PROCEDURE

1 Form the circuit as shown in Fig 1.

2 Note down the name-plate details of the transformer. (Table 2)

Table 1

Sl. No.	Load (Lamp)	Secondary Terminal Voltage VS	Change of volts VO-VS	Regulation
1	No load VO			
2	1/4 F.L.			
3	1/2 F.L.			
4	3/4 F.L.			
5	F.L.			

Check the auto-transformer Tr2 is set at zero volts output position.

3 Switch on 'S1' and adjust the voltage of primary to rated secondary voltage (Vo) of transformer.

4 Close the load switch S2

5 Adjust the lamp load as indicated in Table 1 and record the secondary voltages at each load. (Vs)

6 Calculate % of regulation at different resistive loads.

$$\left(\%\text{ of regulation} = \frac{V_o - V_s}{V_s} \times 100\right)$$

7 Put the inductive load with lamp bank (mixed load) so that the load power factor is lagging.

Fig 1

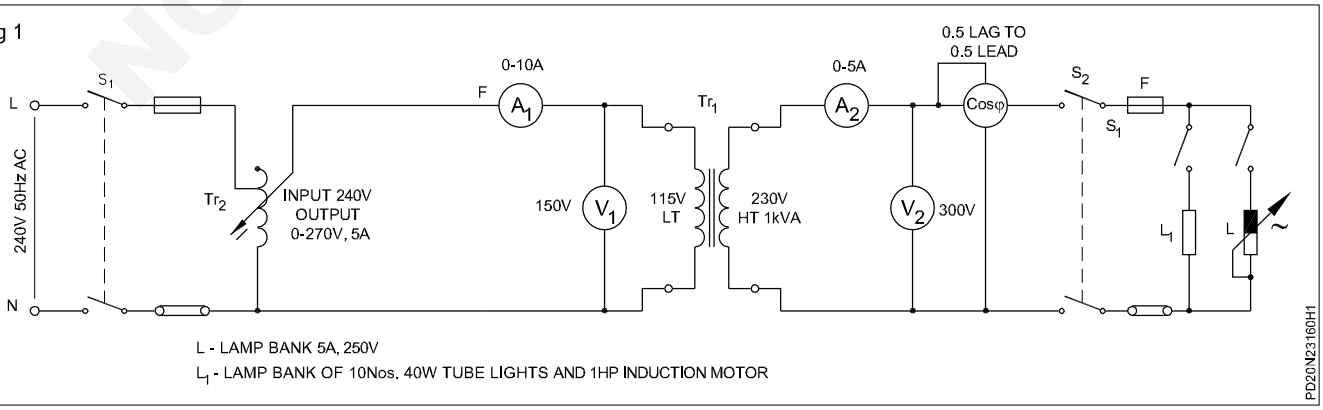
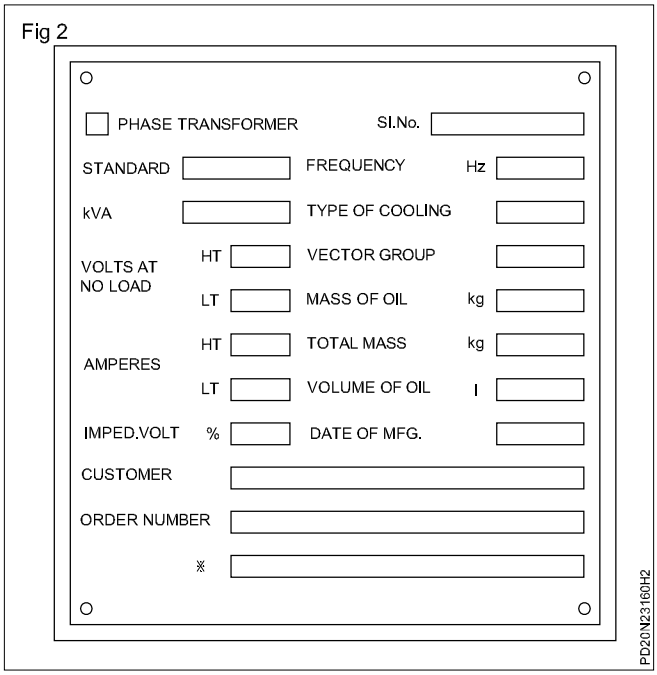


Table - 2

Fig 2



8 Gradually increase the mixed load and measure the terminal voltage, power factor and record in Table 3. Calculate the % of regulation at different loads and power factors.

9 Describe the relationship between p.f. and % of regulation when P.F. changes. Switch off 'S2' and 'S1'.

Table 3

Sl. No.	Load (Mixed) A_2	V_s	PF	Change of volts	Regulation
1					
2					
3					

— — — — —

Perform series and parallel operation of two single phase transformers

Objectives: At the end of this exercise you shall be able to
- **connect two single phase transformers in parallel**
- **connect two single phase transformers secondary in series.**

Requirements

Tools/Instruments

- Voltmeter MI, 150V - 1 No.
- Voltmeter MI, 300V - 2 Nos.

Materials

- ICDP switch 16A 250V 50Hz - 4 Nos.
- Connecting cables - as reqd.

Equipment/Machines

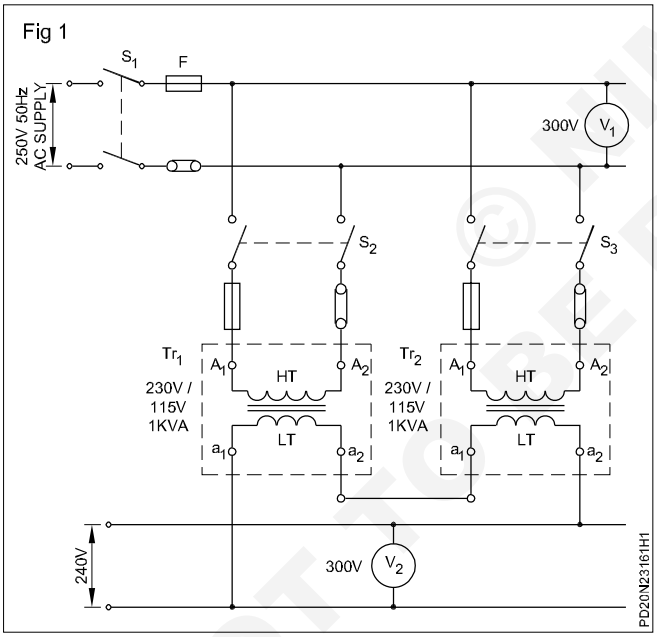
- Single phase transformer 230/115, 1 KVA 50 H1. - 2 Nos.
- DC supply 12V/Battery 12V - 1 No.

PROCEDURE

TASK 1 : **Connect the transformer secondary in series**

1 Connect the transformer as per diagram. (Fig 1)

Fig 1



2 Close the switches S_1, S_2 and S_3.

3 Measure the primary voltage V_1 and secondary voltage V_2 and record in Table 1

Table 1

	Transformer in series	
	Primary V_1	**Secondary V_2**
Tr_1		
Tr_2		

4 Disconnect the transformers by opening S3, S2 and S1.

Table 2

Sl. No.		Type of cooling	
KVA		Frequency	
		Date of MFG	
AT NO LOAD VOLTS	HT		
	LT		
AT NO LOAD CURRENT	HT		
	LT		

— — — — —

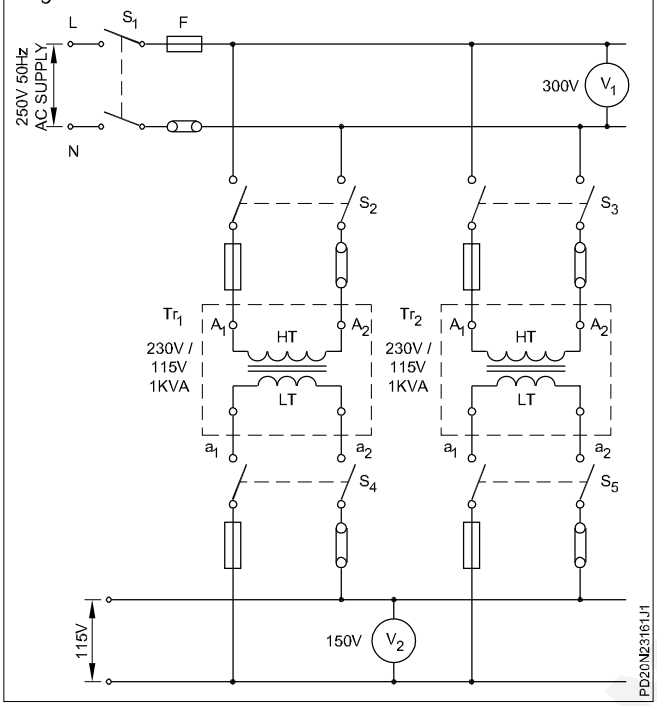
TASK 2 : **Connect the transformer in parallel**

1 Read and record the name-plate details of both the transformers, Tr_1 & Tr_2 in table 2.

2 Determine the polarity of the two given tranformers.

3 Connect the switches, transformers and meters as per diagram. (Fig 1)

Fig 1



4 Keep all the switches open.

5 Ensure that the transformers are identical for parallel connections.

6 Connect transformer Tr_1 to the bus bar closing the switches S_1 & S_2. Measure the primary voltage V_1 and record in Table 3

Table 3

Transformer in parallel		
	Primary V_1	**Secondary V_2**
Tr_1 Tr_2		

7 Check the secondary voltage of Tr_1 and record it table 2.

8 Close the switch S3 and check the secondary voltage of the transformer Tr_2 and record. (Table 2)

9 Close the switch S_4 and S_5 and measure the secondary bus bar voltage and record in table 3.

10 Switch off all the switches and disconnect both the transformers.

CONCLUSIONS

11 The effect on secondary voltage of transformers when connected in series is

_____

_____

_____

12 The effect on the secondary voltage of transfomers when connected in parallel is

_____

_____

_____

— — — — —

Verify the terminals and accessories of three phase transformer HT and LT side

Objectives: At the end of this exercise you shall be able to
- **read and interpret the name plate details of a three phase transformer**
- **verify the terminals of HT and LT winding**
- **Identify the accessories of a three phase transformer.**

Requirements

Tools/Instruments

- DE Spanner Set 5mm to 20mm - 1 Set
- Insulated cutting pliers 200mm - 1 No.
- Screw driver 200mm - 1 No.
- M.I.voltmeter 0-500 V - 1 No.
- Multimeter - 1 No.

Equipment/Machines

- 3 - Phase transformer 415/240V, 3 KVA - 1 No.
- 3 - Phase transformer Input 415 V
  Output 0-500 V, 3 kVA - 1 No.

Materials

- Test lamp 40 W, 230 Volts - 2 Nos.
- Connecting leads - as reqd.

PROCEDURE

TASK 1 : **Verify the terminals of three phase transformer**

1 Note down the name plate details and enter in Table 1

Table 1

Name plate details

SlNo	: _____	Type of cooling	: _____
KVA	: _____	Mass of Coil	: _____
Volts HT	: _____	Total mass	: _____
LT	: _____	Date of MFG	: _____
Amps HT	: _____	Volume of oil	: _____
LT	: _____		
Frequency	: _____		

2 Check the continuity test using a multimeter to find out the two groups of terminals. (Fig 1)

3 Apply 15V 3f supply to U_1, V_1 and W_1 by switching on switch 'S'.

4 Measure the voltage between V_2 and W_2 and between V_2 and U_2. If the voltmeter shows less than 15 volts then those windings are LT winding. If the voltmeter shows more than 15 Volts then those windings are HT winding. (Fig 2)

Fig 1

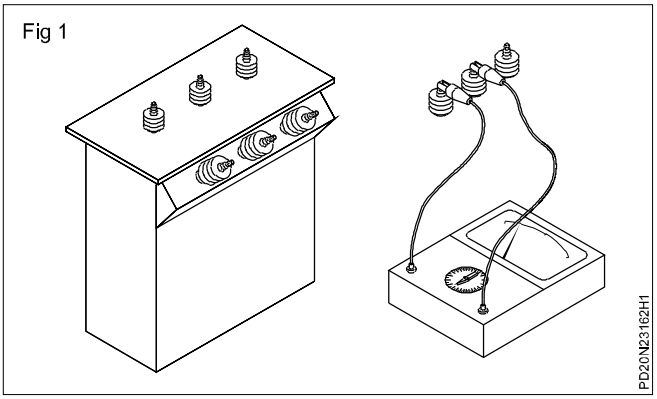


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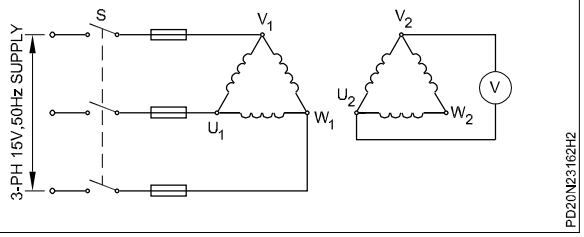
Fig 2



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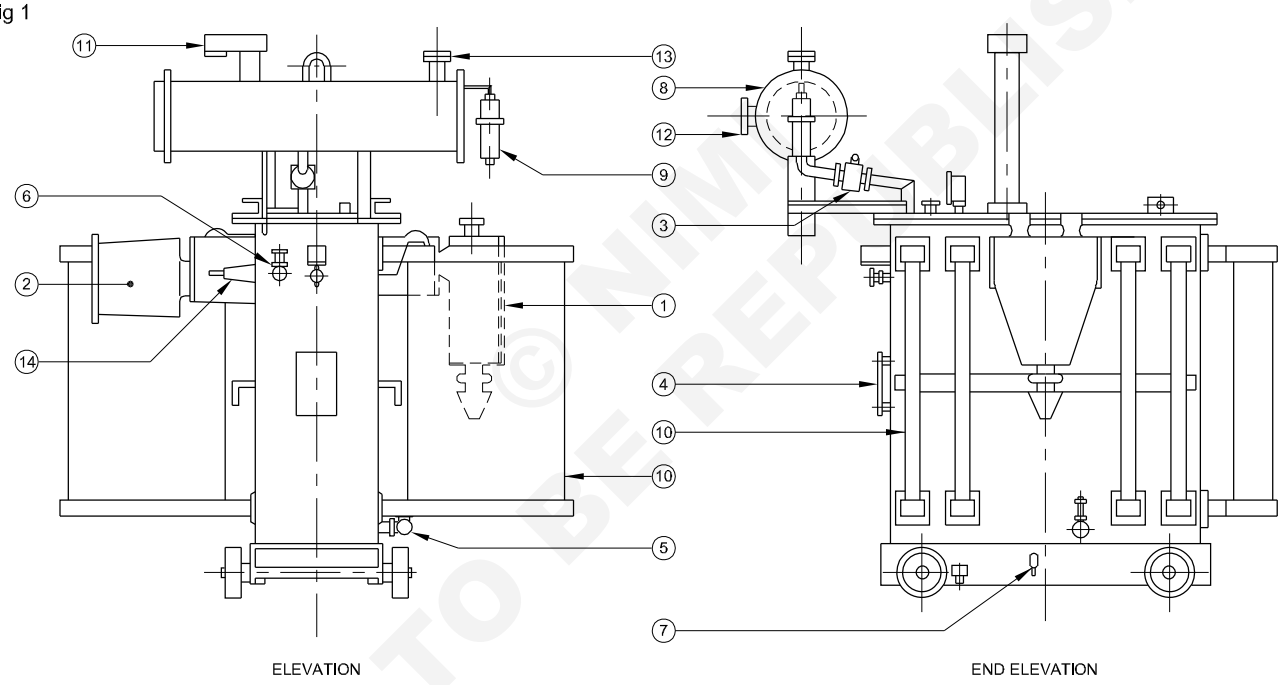
TASK 2 : **Identify the accessories of 3 phase transformer**

1 Get permission to enter the 11 KV transformer substation yard from the appropriate authority

2 Identify the following accessories of a 100KVA three phase transformer. (Fig 1)

- a HV & LV Bushing
- b Buchholz relay
- c Conservator
- d Breather
- e Cooling pipes
- f Explosion vent with oil gauge
- g Earthing terminals
- h Oil level indicator.

Fig 1



No.	ACCESSORIES
7	EARTHING TERMINALS ON BOTH SIDES
6	FILTER VALVE
5	DRAIN VALVE
4	TERMINAL MARKING AND DIAGRAM PLATE
3	BUCHHOLZ RELAY
2	L.V TERMINALS IN BUS DUCT
1	H.V.CABLE BOX

No.	ACCESSORIES
14	L.V. BUSHING
13	FILLING HOLE WITH CAP
12	OIL LEVEL INDICATOR
11	EXPLOSION VENT WITH OIL GAUGE
10	COOLING PIPES
9	DEHYDRATING SILICA-GEL BREATHER
8	OIL CONSERVATOR

ACCESSORIES OF 3Ø TRANSFORMER

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Perform 3 phase operation (i) delta - delta (ii) delta - star (iii) star-star (iv) star - delta by use of three single phase transformes

Objectives: At the end of this exercise you shall be able to
- **connect three single phase transformers to 3-phase supply with different types of primary and secondary connection**
- **measure the primary and secondary line voltages in each type of connection**
- **determine the line voltage ratio and compare with the theoretical ratio values.**

Requirements

Tools/Instruments

- Electrician tool kit - 1 No.
- Voltmeter M.I. - 0 to 500V - 1 No.
- Voltmeter M.I. - 0 to 300V - 1 No.

Equipment/Machines

- Single phase transformer 1 kVA 415/230 V 50Hz - 3 Nos.

Materials

- Connecting cables - as reqd.
- ICTP switch 500V, 16A, - 2 Nos.
- HRC fuses, 2 Amp - 3 Nos.

PROCEDURE

1 Connect the three single phase transformers and per form polarity test and voltage ratio test.

Note down the voltage ratio of each transformer in the table.

All the three transformers should have the same voltage ratio and same primary and secondary voltages.

2 Mark the termials of the primary (HT) and secondary (LT) of each single phase transformer as follows.

The Terminal Marking are as per Standards

Terminals	Transformer 1	Transformer 2	Transformer 3
Primary (HT)	1U	1V	1W
	Starting Ending	Starting Ending	Starting Ending
	1.1 1.2	1.1 1.2	1.1 1.2
Secondary (LT)	2U	2V	2W
	Starting Ending	Starting Ending	Starting Ending
	2.1 2.2	2.1 2.2	2.1 2.2

— — — — —

TASK 1 : **Connect the transformers as three phase delta-delta transformer**

1 Connect the dissimilar ends of the primary together. i.e. (Fig 1)

Connect 1.1. of Tr.1 with 1.2 of tr.3 and mark it as 1U

Connect 1.2. of Tr.1 with 1.1 of tr.2 and mark it as 1V

Connect 1.2. of Tr.1 with 1.1 of tr.3 and mark it as 1W

2 Connect the dissimilar ends of the secondary windings. i.e.

Connect 2.1. of Tr.1 with 2.2 of tr.3 and mark it as 2U

Connect 2.2. of Tr.1 with 2.1 of tr.2 and mark it as 2V

Connect 2.2. of Tr.2 with 2.1 of tr.3 and mark it as 2W

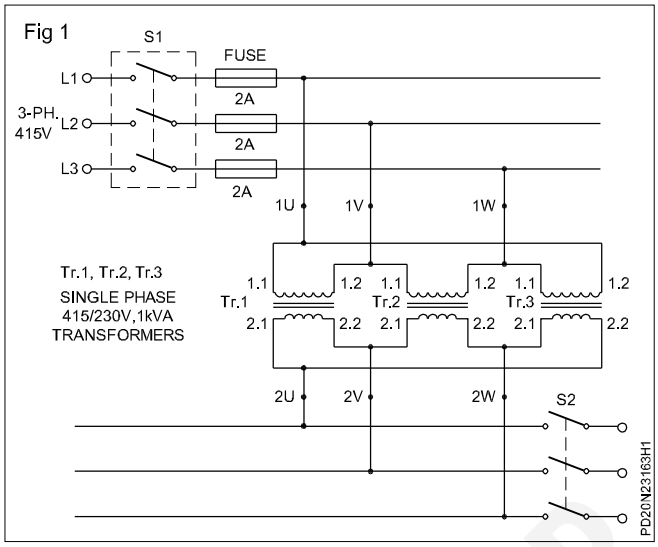
3 Connect 1U, 1V, 1W to ICTP switch S1.

4 Connect a voltmeter 0-500V across 1U and 1V.

5 Connect a voltmeter 0-300V across 2U and 2V.

6 Close the switch S1 and Note down the primary line voltage and secondary line voltage in tabular column under Delta-Delta connection.

7 Calculate the ratio of secondary line voltage and primary line voltage. Compare the values with Theoretical values.



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TASK 2 : **Connect in star-star connection**

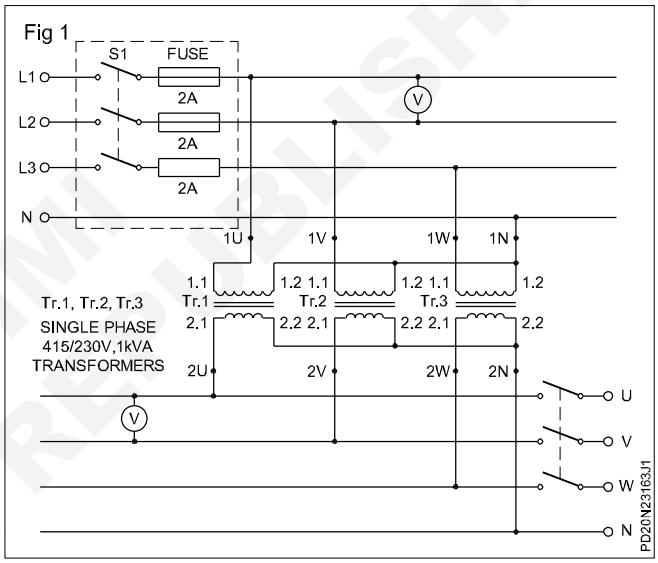
1 Connect any three similar ends of primary winding together. Say connect 1.2 of Tr.1, 1.2 of Tr.2, 1.2 of Tr.3 together and mark the junction as 1N. (Fig 1)

2 Mark 1.1 of Tr.1 as 1U,1.1 of Tr.2 as 1V and 1.1 of Tr.3 as 1W.

3 Connect any three similar ends of secondary winding together. Say connect 2.2 of Tr.1, 2.2 of Tr. 2, 2.2 of Tr.3 together and mark the junction as 2N as shown in circuit 2.

4 Mark 2.1 of Tr.1 as 2U, 2.1 if Tr.2 as 2V and 2.1 of Tr.3 as 2W.

5 Repeat the steps 3,4,5,6,7 of Task 1.



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TASK 3 : **Connect in star-delta connection**

1 Connect three similar terminals of the primary windings together. Say connect 1.2 of Tr.1, 1.2 of Tr.2, 1.2 of Tr.3 and mark the junction as 1N. As shown in Fig 1.

2 Mark 1.1 of Tr.1 as 1U,1.1 of Tr.2 as 1V and 1.1 of Tr.3 as 1W.

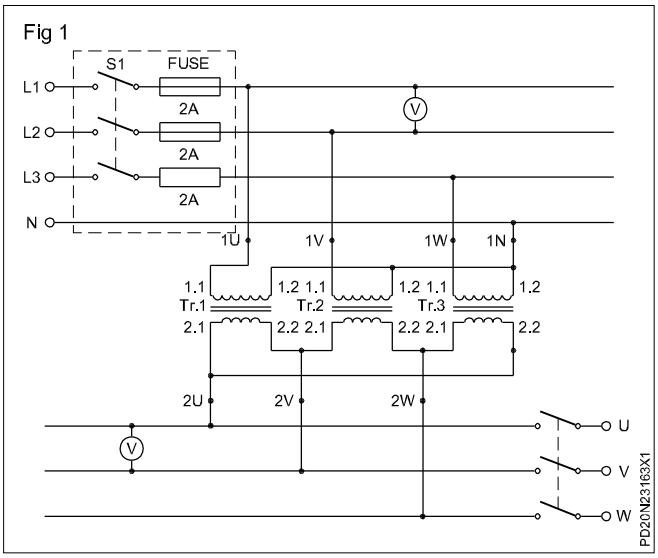
3 Connect the dissimilar terminals of the secondary windings.

Connect 2.1. of Tr.1 with 2.2 of tr.3 and mark it as 2 U

Connect 2.2. of Tr.1 with 2.1 of tr.2 and mark it as 2 V

Connect 2.2. of Tr.2 with 2.1 of tr.3 and mark it as 2 W

4 Repeat steps 3, 4, 5, 6, 7 of Task 1.



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TASK 4 : **To connect in delta-star connection**

1 Connect the dissimilar terminals of the primary windings as follows. (Fig 1)

Connect 1.1. of Tr.1 with 1.2 of tr.3 and mark it as 1U

Connect 1.2. of Tr.1 with 1.1 of tr.2 and mark it as 1V

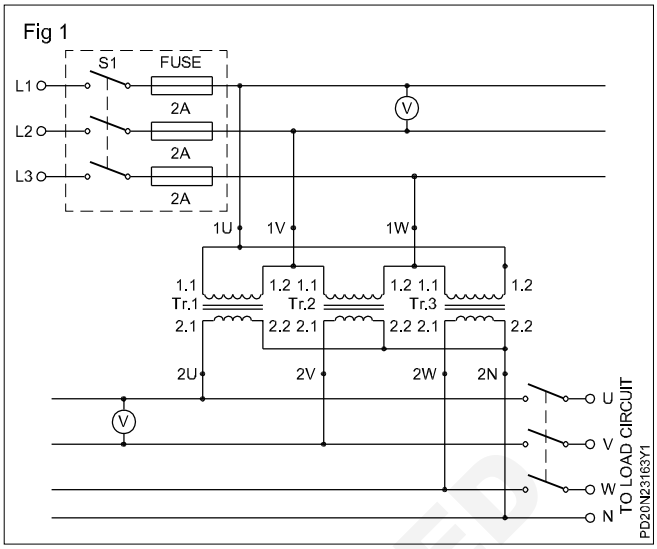
Connect 1.2. of Tr.2 with 1.1 of tr.3 and mark it as 1W

2 Connect the three similar terminals of secondary windings together. Say connect 2.2 of Tr.1,2.2 of Tr.2, 2.2 of Tr.3 and mark the junction as 2N as shown in Fig 4.

3 Mark2.1 of Tr.1 as 2U, 2.1 of Tr.2 as 2V and 2.1 of Tr.3 as 2W.

4 Repeat steps 3,4,5,6,7 of Task 1.

Fig 1



Voltage ratio of each transformer K =.....

Tabular Column

Type of Connection	**Primary Line Voltage**	**Secondary Line Voltage**	**Line Voltage Ratio (Theoretical)** Secondary Line Voltage / Primary Line Voltage	**Line Voltage Ratio (Practical)**
Delta - Delta				
Star - Star				
Star - Star				
Delta - Star				

If a 3 single phase transformer is available with six secondary terminals brought out then follow the same procedure as given in above tasks with the following given terminal markings.

	Transformer	**Windings 1**	**Transformer**	**Windings 2**	**Transformer**	**Windings 3**
	Starting	Ending	Starting	Ending	Starting	Ending
Primary (HT)	1.1U	1.2U	1.1V	1.2V	1.1W	1.2W
Secondary (LT)	2.1U	2.2U	2.1V	2.2V	2.1W	2.2W

— — — — —

Perform BDV (Dielectric strength) and water particle content test of transformer oil

Objectives: At the end of this exercise you shall be able to
- **conduct field test on the transformer oil**
- **conduct crackle test on transformer oil**
- **connect dielectric test on the transformer oil using standard test set.**

Requirements

Tools/Instruments

- Glass tumbler - 1 No.
- Pipette - 1 No.
- 200mm dia. metal tube with one side closing - 1 No.
- Insulated piler - 1 No.
- 100 mm connector screw driver - 1 No.
- Double end electrician knife - 1 No.

Equipments/Machines

- Standard transformer oil test kit with it's accessories - 1 No.
- Electric heater 1000 watts/250V - 1 No.

Materials

- Samples transformer oil (different samples) - as reqd.
- Distilled water - as reqd.

PROCEDURE

TASK 1 : **Conduct field test**

1 Collect a glass tumbler, pipette, oil sample and distilled water on the work bench.

2 Fill the glass tumbler with the distilled water to 3/4th level.

3 Take a sample drop of transformer oil through a pipette and drop a single drop on the distilled water.

4 Observe, the field of the oil surface and record the field diameter and shape.

   a The shape of the oil drop ....

   b The dia for the field .....

   c Condition of oil .... good/bad.

If the shape of drops retained, the oil is good. If the shape is flattened and the drop occupies the area of diameter less than 18mm, the oil may be used. If it is more, it is not suitable and it has to be reconditioned.

— — — — —

TASK 2 : **Conduct Crackle test**

1 Collect, steel tube, heater and a sample of transformer oil.

2 Heat the close end of steel tube.

3 Pour the oil sample into the tube.

4 Take the open end of the tube to the ear and hear the sound.

5 Record the sound heard.

   a Sound heard .....

   b The condition of the oil is ..

If the oil contains moisture, a sharp crackle sound will be heard. Dry oil will only sizzle.

— — — — —

TASK 3 : **To conduct dielectric test with oil testing kit**

1 Examine the oil testing set and read the instructions given by the manufacturer. (Fig 1)

2 Take a sample of the transformer oil in a clean, transparent and dry glass bottle. If there is a drain valve take the sample from the drain valve.

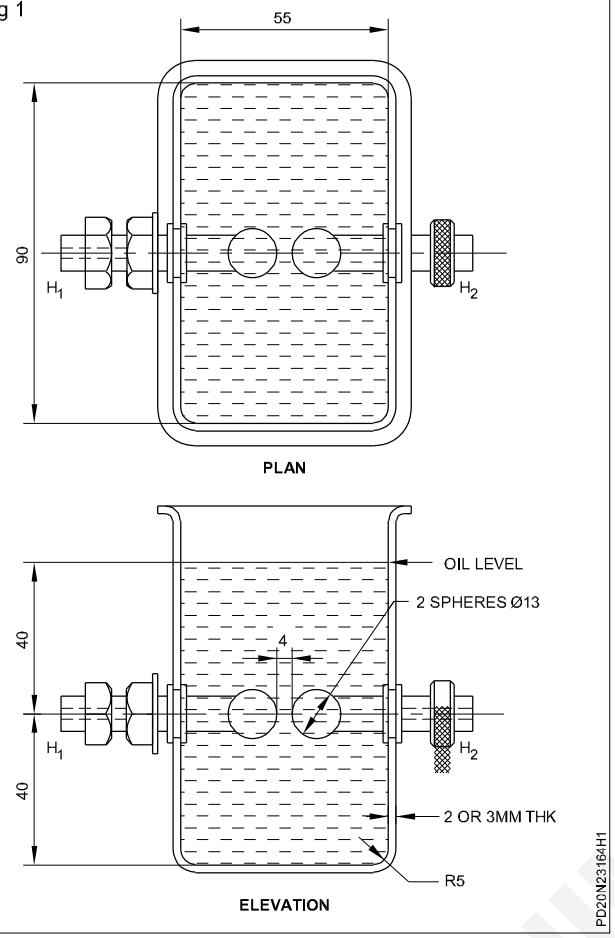
   If it is not possible to take the sample from the drain valve then the sample may be drawn by syphoning off from the conservator tank.

3 Take atleast three samples in three bottles from the transformer to conduct atleast three tests.

4 Clean the standard test cup by washing it with clean oil and adjust the gap of the electrodes in such a way that it should be of 4 mm.

Measure the gap by the calibrated gauge, which is usually supplied with the equipment.

Fig 1



5 Fill the cup with a sample of oil to be tested 1 cm above the electrodes or the marked level on the cup.

6 Close the cup with a clean cover and allow 5 minutes for the oil to settle so that all air bubbles may disappear.

7 Make sure that the test area is clear of all the other persons.

8 Set voltage regulation at zero position.

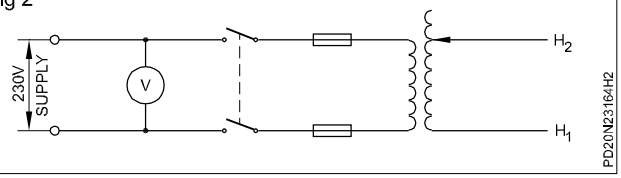
9 Switch 'ON' the supply.

10 Raise the voltage gradually from zero so that the full voltage is reached within 20 to 30 seconds.

It is quite possible that a spark may occur at a very early stage i.e even 20 kV due to some extraneous matter like microscopic strands of cotton, dust etc. which have a tendency to get aligned along the strong electrostatic field in the spark gap. It may burn out and may not affect the test.

11 Raise the voltage until the final breakdown of the oil. The circuit breaker will get tripped. Simultaneously watch the voltmeter and note the readings of the breakdown voltage. (Fig 2)

Fig 2



After sparking the oil near the electrode will turn black in colour.

12 Repeat the steps 5 to 11 with oil in the second sample.

Note that the breakdown voltage of the first and second samples should be approximately equal.

13 Prepare the test for the third sample.

14 Conduct the test by increasing the test voltage up 40 KV.

15 Apply the test voltage for about one minute and observe that there is no sparking.

Note that good oil should withstand 40 kV for one minute.

Conclusion

Since the water is heavier than oil, it settles down at the bottom of the tank.

16 If the tested oil is in good condition, fill this oil in the transformer tank up to the oil level marked on the body of the transformer tank.

— — — — —

Video demonstration of filtering of transformer oil

Objectives: At the end of this exercise you shall be able to
- **instructor may collect video for filtering of transformer oil.**

Requirements

Equipments/Machines		Materials	
• Projector withs accessories	-1No.	• Video for filtering of transformer oil	-1No.

PROCEDURE

1 Ensure proper safety measures, including wearing personal protective equipment (PPE).

2 Place oil filtering equipment near the transformer.

3 Check the equipment for cleanliness and proper functioning.

4 De-energize and isolate the transformer from the power source.

5 Open the drain valve on the transformer to allow the oil to drain into a collection container.

6 Pass the drained oil through a coarse filter to remove larger particles and debris.

7 Connect the oil filtering equipment to the transformer's oil inlet and outlet valves.

8 Start the filtration system, which typically involves using a pump to circulate the oil through a series of filters.

9 Use appropriate filters based on the required level of filtration and the type of impurities present (e.g., particulate, moisture, dissolved gases).

10 Monitor the filtration process closely, ensuring that the oil flows smoothly through the filters.

11 Filters may need to be changed or cleaned periodically depending on their design and the level of contamination.

12 If necessary, use a vacuum chamber or degassing equipment to remove dissolved gases from the oil.

13 Regularly sample the filtered oil and test its quality using appropriate methods like dielectric strength testing and moisture content analysis.

14 Once the oil meets the required quality standards, close the drain valve and disconnect the filtering equipment.

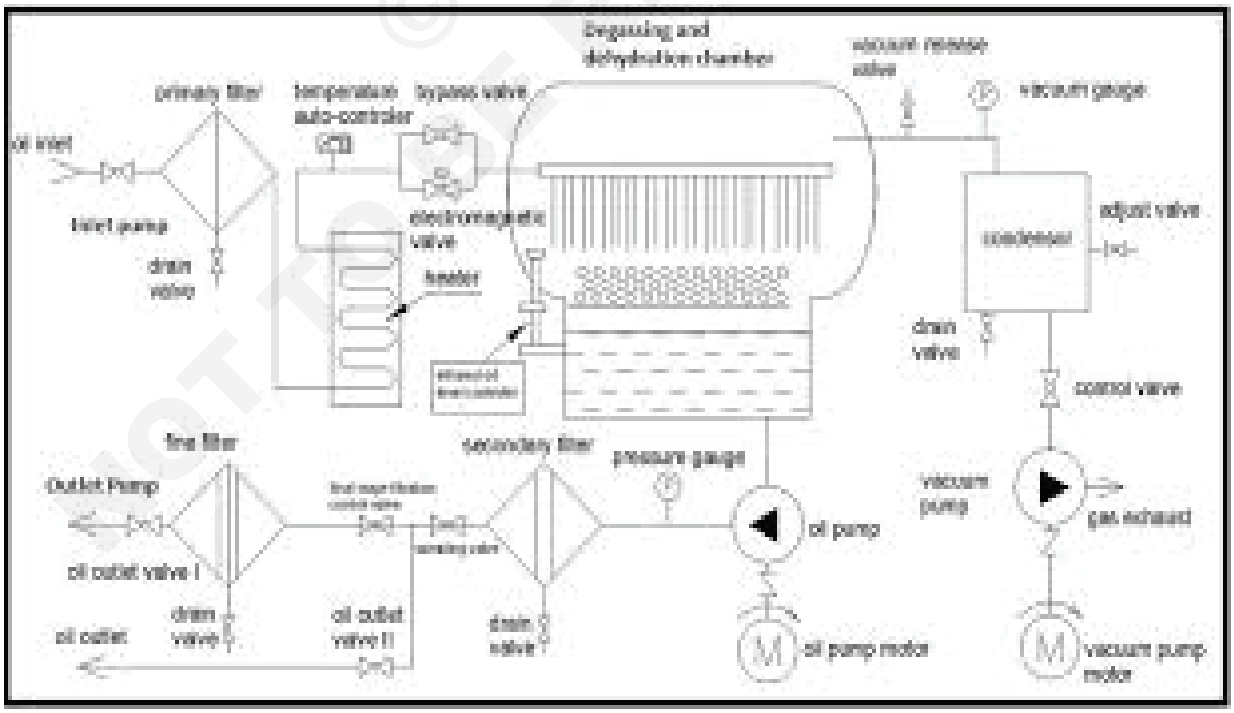
15 Refill the transformer with the filtered oil up to the appropriate level.

16 Re-energize and bring the transformer back into service following standard operating procedures.

17 Maintain detailed records of the filtration process, including dates, oil quality test results, filter change intervals, and any observations.

Fig 1

Fig 2



Carry out routine tests of transformer to check operational performance

Objectives: At the end of this exercise you shall be able to
- **understand routine tests of transformer.**

Requirements

Tools/Instruments	Equipments/Machines
• Safety gear including safety gloves safety glasses and protective clothing	• Digital multimeter • Transformer turn ratio meter • Insulation resistance tester • Power Quality Analyser

PROCEDURE

- Measurement of Transformer Winding Resistance (ExNo : 168)

  Documentation: Have the transformer's technical documentation, including specifications and manufacturer guidelines.
- Insulation Resistance Test: (See Ex No :167)

  Disconnect the transformer from the power source.

  Measure the insulation resistance between windings and to ground using a megger.

  Ensure the resistance values meet or exceed specified levels.
- Transformer Turns Ratio Test: (Exno : 173)

  Isolate the transformer from the power supply.

  Connect a transformer turns ratio meter to measure the turns ratio.

  Verify that the turns ratio matches the specified values.
- Induced Voltage Test : (See Ex No : 176)
- Transformation ratio Test (See Ex No : 173)
- Open circuit Test for measurement of no load loss and current (See Ex No : 175)
- Short circuit Test For measurement of load loss (See Ex No :174)
- Transformer oil BDV Test (See Ex No : 164)

  After these seven routine tests we can assure operational performance of transformer.

Carry out IR & PI test of distribution transformer used in substations using analog& digital megger

Objectives: At the end of this exercise you shall be able to
- **carry out IR test of distribution transformer using analog & digital meggar**
- **carry out PI test of distribution transformer using analog & digital Meggar.**

Requirements

Tools/Instruments

• Analog Meggar	- 1 No.	• Test Record Sheet	- 2 Nos
• Digital Meggar	- 1 No.	• Voltage source DC	
• Clean cloth and cleaning solution	- as reqd.	• Timer	- 1 No.
• Test leads	- 1 No.	• Temperature measurement device	- 1 No.
• PPE Kit			

PROCEDURE

TASK 1 : **Instructor may get permission from Engineer in-charge and take trainees to nearest distribution transformer.**

1 Ensure the transformer is de-energized and all connections are properly isolated.

2 Set the analogue megger to the appropriate test voltage, typically 500V or 1000V.

3 Connect one lead of the megger to the transformer's winding terminal and the other lead to the transformer's grounding point.

4 Rotate the crank on the megger steadily and note the resistance reading on the analogue scale. This reading indicates the insulation resistance.

5 Repeat the test for each winding and phase of the transformer.

6 Compare the measured insulation resistance value with the manufacturer's specifications or industry standards to assess the condition of the insulation

7 Ensure the transformer is de-energized and all connections are properly isolated.

8 Power on the digital megger and set the test voltage, duration, and other settings as required.

9 Connect one lead of the megger to the transformer's winding terminal and the other lead to the transformer's grounding point.

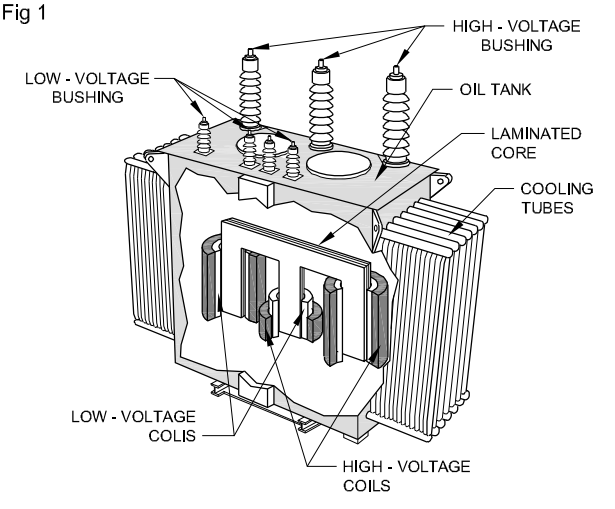
10 Initiate the test on the digital megger. It will apply the test voltage and measure the resistance.

11 The digital megger will display the insulation resistance value directly on its screen.

12 Repeat the test for each winding and phase of the transformer.

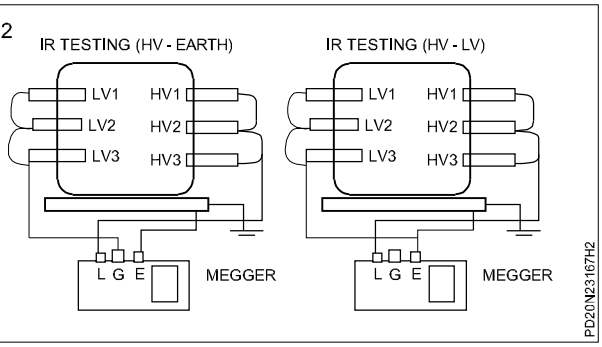
13 Compare the measured insulation resistance value with the manufacturer's specifications or industry standards.(Fig 1&2)

Fig 1



Remember to follow safety protocols while performing these tests, wear appropriate personal protective equipment (PPE), and adhere to the guidelines provided by your organization or industry standards. Insulation resistance values can vary based on factors like transformer size, winding type, and environmental conditions. Always consult relevant documentation for accurate interpretation.

Fig 2



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TASK 2 : **PI test of distribution transformer**

The PI test is used to assess the insulation condition of the transformer.

1 Ensure proper safety measures are in place, including personal protective equipment (PPE) and isolation of the transformer.

2 Connect the test equipment, such as a mega ohmmeter, to the transformer. Make sure all connections are secure.

3 Measure and record the initial resistance value between the windings and ground. This is typically done at 10 minutes and 1 minute.

4 Apply a high DC voltage (usually around twice the transformer's rated voltage) across the insulation for a specific duration, often 10 minutes.

5 After the voltage application, measure the resistance values at regular intervals (e.g., 1 minute, 10 minutes, and 1 hour) and record them.

6 Divide the resistance measured at the 10-minute mark by the resistance measured at the 1-minute mark. This gives you the polarization index (PI) value.

7 Compare the calculated PI value with industry standards. A higher PI value suggests better insulation condition. A typical rule of thumb is that a PI value of 2.0 or greater is usually considered acceptable.

8 If necessary, you can repeat the test on multiple transformers for comparison or conduct periodic tests to monitor insulation degradation over time.

9 Safely discharge the transformer and disconnect the test equipment.

Always refer to the manufacturer's guidelines and industry standards for the specific test procedure and safety precautions. If you're not experienced in conducting these tests, it's advisable to involve a qualified professional.

Tast	Meter type	Voltage applied	Insulation resistance (IR)	Pelanization index (PI)
1				
2				
3				

— — — — —

Measure transformer winding resistance

Objectives: At the end of this exercise you shall be able to
- **disconnect transformer from power source**
- **measure transformer winding resistance.**

Requirements

Tools/Instruments

- Personal protective equipments
- Clean cloth
- Digital low resistance Ohm meter
- Electricians Tool Kit

PROCEDURE

1 Ensure that you are following proper safety guidelines, including wearing appropriate protective gear and disconnecting the transformer from the power source.

2 Set up the necessary equipment, including a low-resistance ohmmeter, Make sure the equipment is calibrated and functioning correctly.

3 Ensure the transformer is fully isolated from the power source and any other circuits to avoid accidents during the measurement process.

4 If the transformer was recently in operation, allow it to cool down to the ambient temperature before proceeding.

5 Identify the winding(s) you want to measure. Transformers typically have primary and secondary windings. You may need to access the winding terminals, which might involve removing covers or panels.

6 Short-circuit the winding(s) you're measuring to eliminate induced voltage during the resistance measurement. This can be done by connecting the terminals together.

7 Some measurement equipment requires lead compensation to account for the resistance of the connecting leads. Follow the manufacturer's instructions for this step.

8 Connect the measurement equipment to the winding terminals. Apply the appropriate settings on the equipment, such as range and accuracy. Initiate the measurement and record the resistance value.

9 Record the ambient temperature of the transformer and the winding during the measurement. Resistance values are often temperature-dependent, so this information is crucial for accurate calculations.

10 Correct the measured resistance to the reference temperature using the temperature coefficient of the material. Copper has a typical temperature coefficient of 0.00392 per degree Celsius.

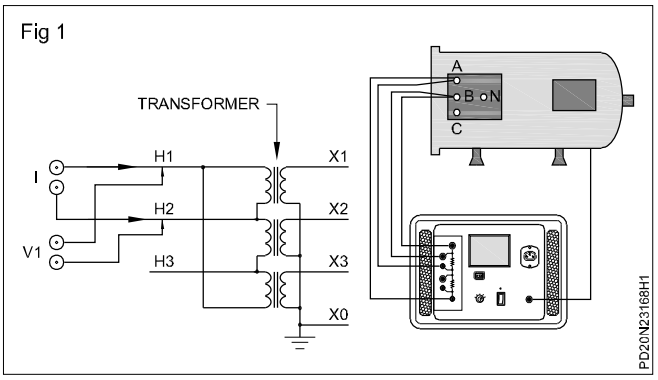
11 Compare the measured resistance with the design or expected values. A significant deviation might indicate a problem with the transformer winding, such as damage or degradation.

12 Record all measurements, calculations, and observations. This documentation can be valuable for future reference or troubleshooting.

13 Once the measurements are complete, ensure that all connections are properly disconnected and the transformer is safe to be reconnected to the power source.

Always remember that working with transformers involves electrical hazards. If you're not familiar with the process, it's recommended to seek assistance from qualified professionals or technicians or your instrutor.

Fig 1



Carryout IR test of individual bushings of distribution transformer

Objectives: At the end of this exercise you shall be able to
- **carryout IR test of individual bushings of distribution transformer.**

Requirements

Tools/Instruments

- Meggar - 1No.
- Test leads
- Voltage source
- Clean cloth and cleaning solution
- Personal Protective equipments.
- Electricians Tool Kit.

PROCEDURE

1 Ensure the transformer is de-energized and isolated from the power source. Follow proper safety protocols, including wearing appropriate protective gear.

2 Set up the insulation resistance test equipment, including the insulation resistance tester (mega ohmmeter) and necessary cables. Ensure the equipment is calibrated and functioning correctly.

3 Disconnect the bushing from any connected circuitry. If applicable, remove any covers or protective layers to access the bushing terminals.

4 Clean the bushing terminals and surrounding area to remove dirt, moisture, or any contaminants that could affect the test results.

5 Connect the cables from the insulation resistance tester to the terminals of the bushing. Connect the positive lead to the bushing's high-voltage terminal and the negative lead to the ground or low-voltage terminal.

6 Set the test parameters on the insulation resistance tester, including the test voltage (usually 500V or 1000V for low-voltage equipment) and the duration of the test.

7 Initiate the test on the insulation resistance tester. The tester will apply the chosen test voltage across the terminals of the bushing and measure the insulation resistance. The measured resistance value will indicate the condition of the insulation.

8 Record the insulation resistance reading from the tester. This reading gives an indication of the insulation's quality. Higher resistance values are generally desirable, indicating better insulation.

9 Compare the measured resistance value with the manufacturer's specifications or industry standards to determine if the bushing's insulation is within an acceptable range.

10 If the measured resistance is significantly lower than expected or falls below a predetermined threshold, it may indicate insulation degradation or moisture ingress. Further investigation or maintenance might be required.

11 Document the test results, including the measured insulation resistance value, date of the test, and any relevant observations.

12 After completing the test and recording the results, reassemble the bushing by replacing any covers or protective layers that were removed earlier.

13 Ensure that all equipment is properly disconnected, and safety measures are followed before leaving the testing area.

Remember, the specific steps and recommended practices might vary based on the equipment manufacturer's guidelines and local regulations. Always follow the appropriate safety precautions and use suitable testing equipment.

The insulation resistance of a transformer is measured as follows.

Between the HV winding and tank, the LV winding is being grounded.

Between the LV winding and tank, the HV winding is being grounded.

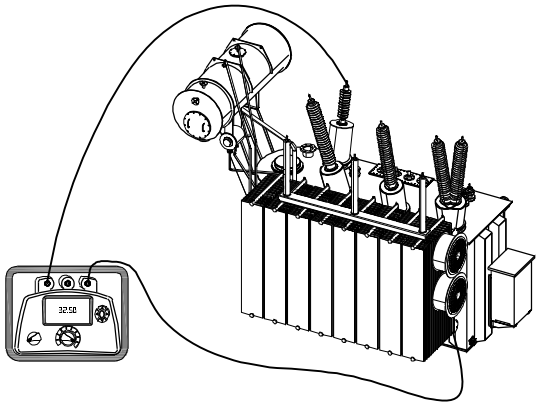
Between the LV/HV windings collectively, and the tank grounded.

Insulation value of the transformer winding (ohms)

Between HV-E between LV-E between HV-LV

Insulation resistance test readings.(Fig 1)

Fig 1



Identify phase and neutral bushings of HT & LT side of the distribution transformer

Objectives: At the end of this exercise you shall be able to
- **read and interpret the name plate details of a three phase transformer**
- **verify the terminals of HT and LT winding.**

Requirements

Tools/Instruments

- DE Spanner Set 5mm to 20mm - 1 Set
- Insulated cutting pliers 200mm - 1 No.
- Screw driver 200mm - 1 No.
- M.I.voltmeter 0-500 V - 1 No.
- Multimeter - 1 No.

Equipment/Machines

- 3 - Phase transformer 415/240V, 3 KVA - 1 No.
- 3 - Phase transformer Input 415 V Output 0-500 V, 3 kVA - 1 No.

Materials

- Test lamp 40 W, 230 Volts - 2 Nos.
- Connecting leads - as reqd.

PROCEDURE

TASK 1 : **Verify the terminals of three phase transformer**

1 Note down the name plate details and enter in Table 1

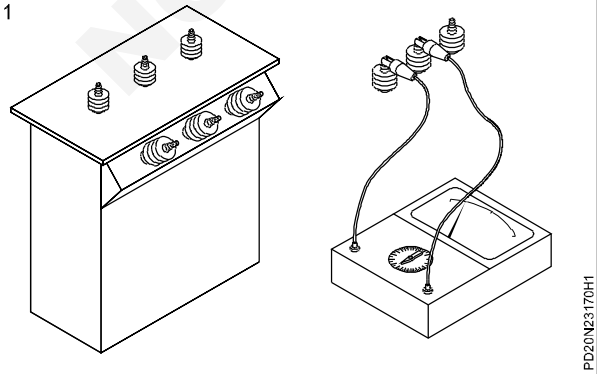
Table 1

Name plate details

SlNo	:	_____	Type of cooling	:	_____
KVA	:	_____	Mass of Coil	:	_____
Volts HT	:	_____	Total mass	:	_____
LT	:	_____	Date of MFG	:	_____
Amps HT	:	_____	Volume of oil	:	_____
LT	:	_____			
Frequency	:	_____			

2 Check the continuity test using a multimeter to find out the two groups of terminals. (Fig 1)

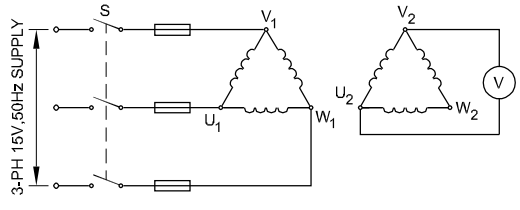
Fig 1



3 Apply 15V 3f supply to U1, V1 and W1 by switching on switch 'S'.

4 Measure the voltage between V2 and W2 and between V2 and U2. If the voltmeter shows less than 15 volts then those windings are LT winding. If the voltmeter shows more than 15 Volts then those windings are HT winding. (Fig 2)

Fig 2



Identify various components of cooler control system of the transformer

Objectives: At the end of this exercise you shall be able to
- **identify components of cooler control system of transformer.**

Requirements

Tools/Instruments

- PPE kit
- A4 paper - 2 Nos.
- Pen - 1 No.

Instructor may take trainees to nearest substation and help to identify different components of cooler control system of transformer.

PROCEDURE

1 **Temperature Sensors:** These sensors are used to monitor the temperature of the transformer, both in the winding and oil.

2 **Cooling Fans:** The cooling fans help dissipate heat from the transformer by blowing air over the cooling fins or radiators.

3 **Control Panel:** The control panel houses the necessary electronics and controls to manage the cooling system.

4 **Thermostat:** The thermostat regulates the operation of the cooling fans based on the transformer's temperature readings

5 **Cooling Fins/Radiators:** These are metal structures attached to the transform that increase the surface area for better heat dissipation.

6 **Pumping System:** In some cases, transformers use oil pumps to circulate the cooling oil more efficiently.

7 **PLC or Microcontroller:** These are used for automating the cooling system a implementing control algorithms.

8 **Communication Interfaces:** Modern cooler control systems may have communication interfaces for remote monitoring and control.

These components work together to ensure the transformer operates within safe temperature limits and efficiently dissipates the generated heat.

Fig 1

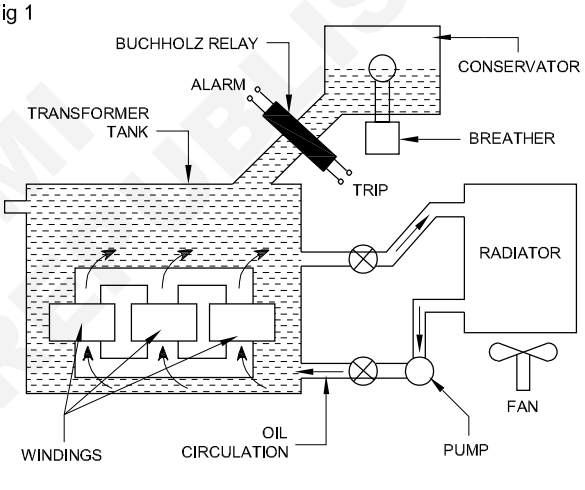
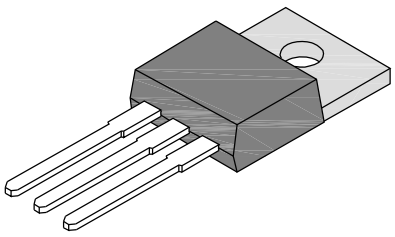


Fig 2



Carry out the manual and auto operation of a fan from a transformer marshalling kiosk

Objectives: At the end of this exercise you shall be able to
- **manual and Auto operation of fan from transformer marshalling kiosk.**

Requirements

Tools/Instruments

• Paper	- 3 Nos	• Scale 300mm	- 1 No.
• Pen	- 1 No.	• PPE kit	- 1 No.
		• Electrician tool kit	- 1 No.

PROCEDURE

Manual operative

1 Ensure the power supply to the transformer marshalling kiosk is stable and within the specified range.

2 Locate the control panel inside the kiosk that is responsible for the fan's operation.

3 Identify the control switches or buttons for the fan. There might be a switch for turning the fan on/off and another for controlling its speed.

4 If the fan is currently off, flip the switch to the "On" position.

5 If there's a speed control switch, set it to the desired speed (low, medium, high).

6 Monitor the fan to ensure it starts operating at the selected speed.\

"Automatic Operation:"

1 Verify that the automatic control system for the fan is properly configured and functional.

2 Ensure the power supply to the transformer marshalling kiosk is stable and within the specified range.

3 The automatic control system might be connected to a temperature or humidity sensor. Ensure these sensors are properly calibrated and operational.

4 The automatic system might also be connected to a timer or a programmable logic controller (PLC) that regulates the fan's operation based on predefined schedules.

5 If the system is sensor-based, ensure that the sensor data is being accurately read and processed by the control system.

6 If the system is timer or PLC-based, ensure that the schedule is correctly set for the fan to turn on and off according to the desired conditions.

7 Monitor the fan's operation to ensure it is responding correctly to the automatic control inputs.

Remember, specific steps might vary based on the design and components of the transformer marshalling kiosk and the fan's control system. Always follow the manufacturer's guidelines and any safety procedures in place when operating electrical equipment.(Fig 1)

Fig 1

Perform transformation ratio test

Objectives: At the end of this exercise you shall be able to
- **read and interpret the details of the name-plate of single phase transformer**
- **identify H.T & L.T. winding**
- **determine transformation ratio (turns ratio) by the**
  - **voltmeter method**
  - **ammeter method.**

Requirements

Tools/Instruments

- VoltmeterM.I. 0 - 250/300V - 2 Nos.
- Ohmmeter (0 - 500 ohms) - 1 No.
- Ammeter M.I. type (0 - 10 Amp) - 1 No.
- Ammeter M.I. 100 mA - 1 No.
- Voltmeter M.C. 0-15V - 1 No.

Equipment/Machines

- D.C. supply 12 volts - 1 No.
- Single phase transformer 115/230 volts, 1KVA - 1 No.
- Auto-transformer (IP-240V) OP 0-270V, 5A - 1 No.

Materials

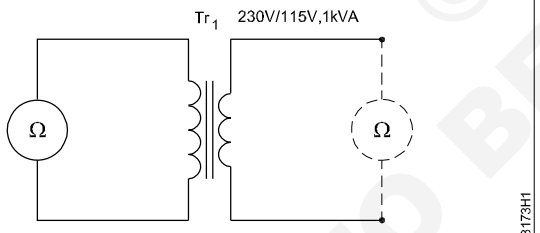
- Knife switch DPST 16A 250V - 1 No.
- Push-button 6A, 250V - 1 No.
- Connecting cables - as reqd.

PROCEDURE

TASK 1 : **Identification of terminals**

1 Find out the corresponding terminals of two windings (H.T. & L.T) with ohmmeter as shown in Fig 1, by checking the continuity.

Fig 1



CIRCUIT FOR IDENTIFICATION OF TERMINALS OF SINGLE PHASE TRANSFORMER

PD20N23173H1

2 Determine HT and LT winding by measuring resistances with the ohmmeter.

L.T. windings will have low resistance in the case of step down transformer.

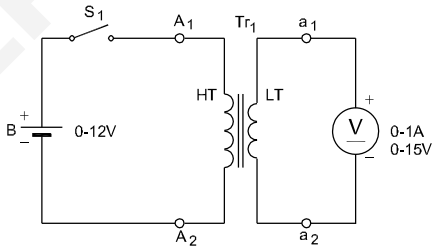
Record resistance of both pairs.

1st pair _____ ohms. This is HT/LT winding.

2nd pair _____ ohms This is HT/LT winding.

3 Connect DC supply to HT through push-button swithch and connect the voltmeter to LT as shown in Fig 2.

Fig 2



NOTE:
INSTEAD OF THE BATTERY DC STABILIZED POWER SUPPLY CAN BE USED

CIRCUIT FOR IDENTIFICATION OF POLARITY OF TRANSFORMER

PD20N23173H2

4 Mark HT terminals as A1 and A2. Mark at LT terminals as a1 and a2.

5 Press the push-button switch. Observe the deflection of the pointer of the voltmeter. If the pointer deflects in the right direction, retain the markings made on terminals.

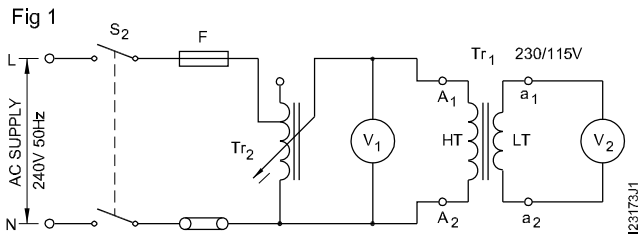
6 Change the voltmeter connections made to LT terminals and change the marking made on the LT terminals if the deflection is in the reverse direction. Now press the push-button switch once again and observe that the voltmeter deflects in right direction.

— — — — —

TASK 2 : **Verification of transformation ratio (by voltmeter method)**

1 Connect the auto-transformer and the voltmeters to the transformer as shown in Fig 1. Check and set the auto-transformer at zero volt output position.

Fig 1



CIRCUIT FOR VERIFICATION OF TRANSFORMATION RATIO

2 Switch on 'S_2' and adjust the autotransformer to get the output voltage V_1 = 100 volts and read V_2 record the value in Table 1.

The output voltage of the auto-transformer should be adjusted to about 50% of the rating of the H.T. side.

3 Set the V_1 value for the values indicated in Table 1 and record the corresponding readings of V_2 in Table 1.

4 Calculate the transformation ratio from the measured V1 & V2 values.

Applying the formula -

$$\text{Transformation ratio} = \frac{V_2}{V_1}$$

Table 1

Sl. No.	V_1	V_2	Transformation ratio $K=V_2/V_1$
1	100 Volts		
2	125 Volts		
3	150 Volts		
4	200 Volts		
5	225 Volts		

5 Compare the calculated transformation ratio with the transformation

6 Transformation ratio calculated

from measurements =

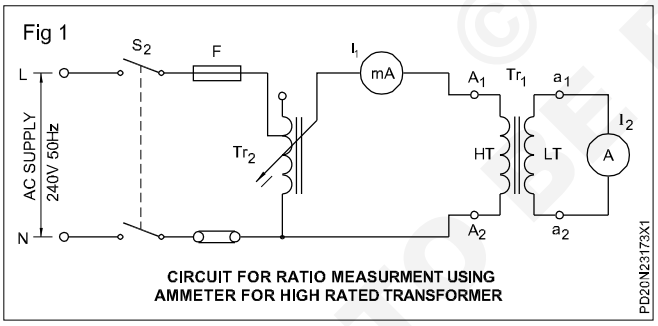
from markings =

— — — — —

TASK 3 : **Verification of transformation ratio (by ammeter method)**

1 Connect the auto-transformer output to the transformer H.T. winding through a milliammeter in the line as shown in Fig 1.

Fig 1



CIRCUIT FOR RATIO MEASURMENT USING AMMETER FOR HIGH RATED TRANSFORMER

The current in the H.T. winding should be kept low, but should be large enough to be measured accurately with a milliammeter.

2 Connect the L.T. winding to the ammeter. The ammeter should carry the rated current of L.T. side.

Use the current transformer and ammeter if the secondary rating is very high.

3 Increase the voltage to give the required current in H.T. winding.

4 Read the L.T. current. Record in Table 2.

5 Change the H.T. current to different values and record the corresponding L.T. current.

Table 2

Sl. No.	I_1	I_2	Transformation ratio $K=I_1/I_2$
1			
2			
3			
4			

6 Verify the transformation ratio with the markings on the name-plate and record your findings.

_____

_____

_____

_____

— — — — —

Carry out short circuit test and measure impendence voltage/ short circuit impedance (principal tap) and load loss

Objectives: At the end of this exercise you shall be able to
- **conduct short circuit test to determine impedance voltage**
- **conduct short circuit test to determine impedance**
- **conduct short circuit test to determine load losses.**

Requirements

Tools/Instruments

- Voltmeter M.I, 100V - 1 No.
- Voltmeter M.1, 150V - 1 No.
- Wattmeter 250V,SA-1250W - 1 No.
- Ammeter M.I. 5A - 1 No.
- Ammeter M.I. 15A - 1 No.
- Frequency meter 45 to 65Hz. - 1 No.
- Power factor meter 0.5 lag-1-0.5 leod 250V rating - 1 No.

Equipment/Machines

- Transformer 100/250V 1 &VA 50 Hz - 1 No.
- Auto-transformer input240V Output 0 to 270V,5A - 1 No.

Materials

- Knife switch DPST 16A 250V - 1 No.
- Connecting cables - as reqd.

PROCEDURE

TASK 1 : **Conduct shot circuit test to determine full load copper loss of a transformer**

Short circuit test

1 Connect the auto-transformer, ammeters, voltmeter and wattmeter in the HT side of the transformer as shown in Fig 1

Ensure the auto-transformer is initially set at zero volt output position.

2 Close the switch S

The secondary is short circuited by the ammeter.

3 Increase the voltage gradually to obtain full load current in the secondary winding of the transformer

4 Observe the wattmeter and record the readings W Copper loss (full load)

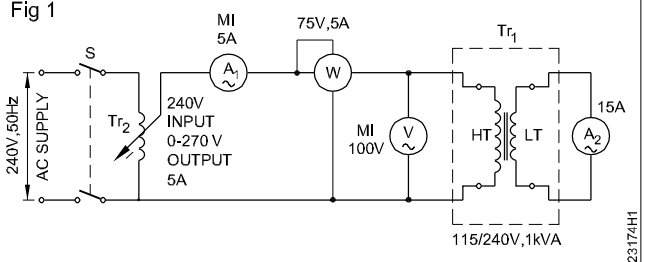
$$\text{Impedance} = \frac{V}{I}$$

$$R = \frac{W}{I^2} \;\&\; Z = \frac{V}{I}$$

$$\text{Impedance} = \frac{\text{Voltage (V)}}{\text{Current (I)}}$$

Sl No	V	I	W	Full load loss	Impedance
1					

Fig 1



SHORT CIRCUIT TEST FOR DETERMINATION OF COPPER LOSS OF A SINGLE PHASE TRANSFORMER

PD20N23174H1

— — — — —

Carryout open circuit test for measurement of no load loss and current

Objectives: At the end of this exercise you shall be able to
- **conduct open circuit test to determine iron or core loss.**

Requirements

Tools/Instruments

- Voltmeter M.I. 100V - 1 No.
- Voltmeter M.I. 150V - 1 No.
- Wattmeter 250V, 5A - 1250W - 1 No.
- Ammeter M.I. 5A - 1 No.
- Ammeter M.I. 15A - 1 No.
- Frequency meter 45 to 55Hz. - 1 No.
- Power factor meter 0.5 lag -1-0.5 lead 250V rating - 1 No.

Equipment/Machines

- Transformer 100/250V 1 kVA 50 Hz - 1 No.
- Auto-transformer input 240V output 0 to 270V, 5A - 1 No.

Materials

- Knife switch DPST 16A, 240V - 1 No.
- Connecting cables - as reqd.

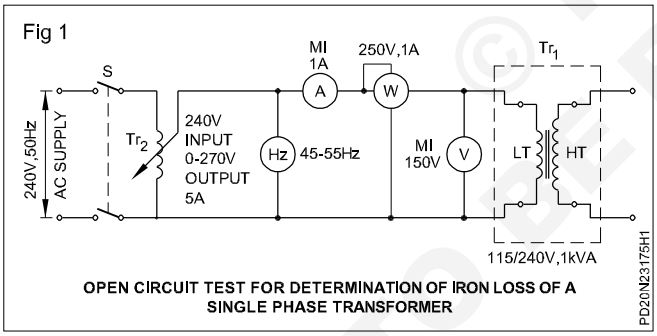
PROCEDURE

TASK 1 : **Conduct open circuit test to determine iron or core loss**

1 Identify the LT and HT windings of the given transformer.

2 Connect the Auto-transformer, frequency meter, ammeter, wattmeter. Voltmeter to the LT side of the transformer as shown in Fig 1.

Fig 1



OPEN CIRCUIT TEST FOR DETERMINATION OF IRON LOSS OF A SINGLE PHASE TRANSFORMER

Ensure that the auto-transformer is initially set at zero volt output position.

3 Close the switch 'S'.

Increase the voltage slowly up to (100%) of the rated value of the transformer L.T.

4 Check for the supply frequency is at rated value.

5 Observe the meters and record the readings in Table.

6 Repeat the above steps for 110% rated value of transformer voltage and record the readings in Table.

TABLE

Sl.No.	Rated	Voltage V	Current A	Total Iron loss W
1	100%			
2	110%			

From the above data the No load loss is equal to iron loss. Since the copper loss is negligible.

— — — — —

Carryout induced voltage test of transformer

Objectives: At the end of this exercise you shall be able to
- **test induced voltage of tranformer.**

Requirements

Tools/Instruments

- Voltmeter - 1No.
- Ammeter - 1No.
- Tachometer - 1No.
- Variable A.C Power Supply - 1No.
- Safety bear like gloves, goggles ets - 1No.
- Documentation
  -Have the transformer's - 1No.
- Specifications and documentation ready.

PROCEDURE

1 Before starting the test, ensure that the transformer is de-energized and disconnected from the power source. Use proper personal protective equipment (PPE) and follow safety guidelines.

2 Set up the necessary equipment for the test, including a variable AC voltage source, a voltmeter, and appropriate cables.

3 If the transformer is a multi-winding type, disconnect all secondary windings from the transformer.

4 Connect the variable AC voltage source to the primary winding of the transformer.

5 Gradually increase the voltage from the source to a specific test level. Typically, this voltage is a percentage of the rated voltage, such as 5% or 10%.

6 Use the voltmeter to measure the voltage induced in the disconnected secondary winding(s).

7 Record the induced voltage readings at different test levels.

8 Compare the induced voltage readings with the transformer's rated voltage and previous test results to identify any abnormalities or potential issues.

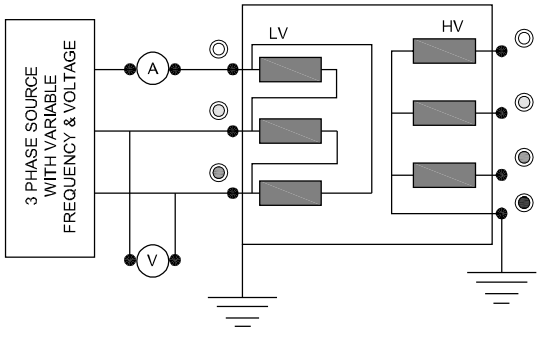
9 Analyze the test data to assess the transformer's condition, efficiency, and any possible defects or insulation problems.

10 After completing the test, disconnect the voltage source and return the transformer to its normal operating condition.

Always follow the manufacturer's guidelines and safety procedures while conducting any test on a transformer. If you are not familiar with the testing procedure, it is advisible to seek assistance from a qualified professional or an experienced engineer.(Fig 1)

voltmeter (V_1)	Ammeter reading (A)	Induced voltage readings (V_2)

Fig 1



Carry out tests on Components/accessories viz., buchholz relay, Temperature indicators, pressure relief devices, oil preservation system etc

Objectives: At the end of this exercise you shall be able to
- **carry out buchholz relay, temperature indicators, pressure relief devices, oil preservation system etc.**

Requirements

Tools/Instruments

• Multi Meter	- 1No.
• Megger	- 1No.
• oil testing kit	- 1No.
• PPE kit	- 1Set.
• Fire extringersher	- as reqd.

Instructor may take trainee to nearest substation on maintenance day, with premission from Engineer in charge as to see there equipments and understanding their function and conducting connected tests.

PROCEDURE

1 Familiarize yourself with the manufacturer's documentation and the specific testing requirements for the Buchholz relay. Ensure that you have the necessary testing equipment and safety precautions in place.

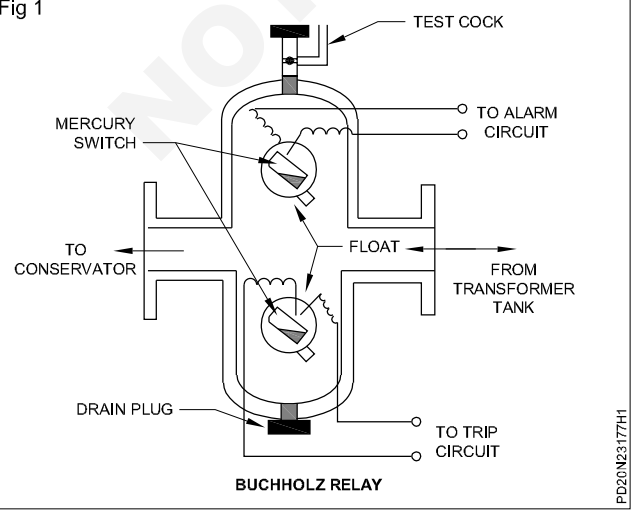
2 Examine the relay for any physical damage, loose connections, or signs of wear. Ensure that it is correctly installed and properly connected.

3 Check the basic functionality of the Buchholz relay by simulating various fault conditions. Verify if it trips as expected when faults are introduced.

4 Measure the insulation resistance between different terminals or windings of the relay using a megohmmeter. This test ensures that there are no electrical leakages.

5 Analyze the insulating oil in the Buchholz relay to ensure its dielectric strength and detect any contamination or degradation.(Fig 1)

Fig 1



BUCHHOLZ RELAY

6 Test the Buchholz relay's response to gas accumulation by injecting a small amount of gas (air or nitrogen) into the relay and observing its reaction.

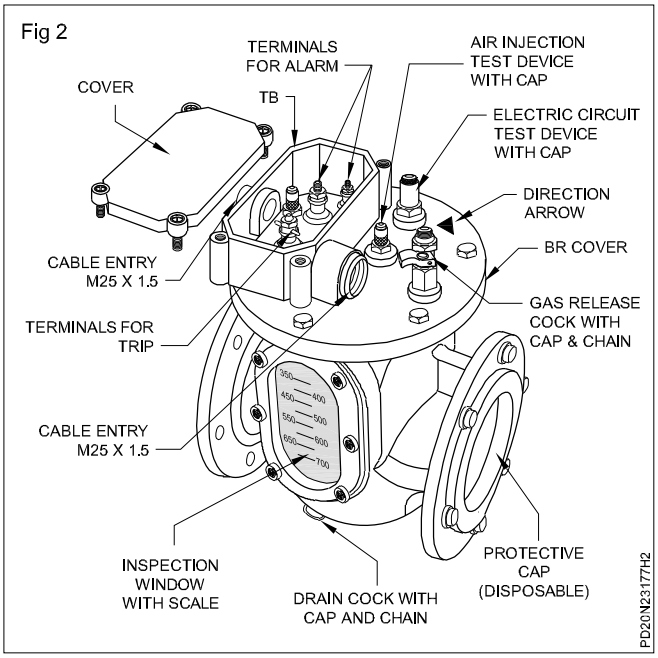
7 Perform a trip test by simulating a fault and verifying that the relay trips and sends a signal to the connected protection system.

8 Check the alarm function of the relay by triggering a fault condition and ensuring that it activates the alarm without tripping the circuit.

9 After testing, reset the relay to ensure that it functions correctly after a fault condition has been cleared.

10 Maintain a detailed record of the test results, including any abnormalities or issues encountered during testing.(Fig 2)

Fig 2



Carry out maintenance of transformer

Objectives: At the end of this exercise you shall be able to
- **carry out hourly maintenance of transformer**
- **carry out daily maintenance of transformer.**

Requirements

Tools/Instruments

- Electrician tool kit - 1 No.

Materials

- Items required for reactivating silica gel.
- Spare relief diaphragm.

Note: The instructor may take the trainess to the transformer yard and demonstrate the maintenance procedures.

PROCEDURE

TASK 1 : **Carry hourly maintenance**

1 Note down the secondary load current of the transformer read by the ammeter provided.

2 Check this value with the rated value as per name plate details.

3 If the load current is more than the rated value then reduce the load on transformer by the following sequence.

a Trip off the circuit breaker

b Switch off the load feeders which are not very essential

c Again charge and switch on the circuit breaker.

4 Record the values of primary line voltage and line current and secondary line voltage and line current and PF in Table 1.

5 Note down the oil temperature which is indicated by thermostat dial or thermometer in Table 1.

Table1

Maintenance chart for hourly maintenance of 3 ϕ transfomer

Sl. No.	Date & Time	Primary Line Voltage		Secondary Line Voltage		Secondary Current		Power Factor	Oil Temp	Re-marks
		Phases	Voltage (V)	Phases	Voltage (V)	Phases	Current in Amps			
1		1U - 1V		2U - 2V		2U				
2		1V - 1W		2V - 2W		2V				
3		1W - 1U		2W - 2U		2W				

— — — — —

TASK 2 : **Carry out daily maintenance of transformer**

1 Inspect the dehydrating breather, by following sequence.

a Check whether the air passages are clear, if not clean it

b Check the colour of the active agent i.e. silicagel

c If the silica gel is pink in colour, reactivate it in following sequence.

2 Collect the sillica gel crystals in a shallow tray and brake them at 200°C.

3 When the crystals become blue in colour, fill the breather with reactivated blue crystals.

4 Inspect the oil level in the transformer.

5 Observe the conservator sight glass and check the oil level of the transformer.

6 If the oil level is low, top up the level through drain value by filling clean transformer oil.

7 If the oil level drops appreciably over a short period, then check the tank for any oil leakage.

8 If there is a leak in the transformer tank, take suitable actions to prevent leakage by consulting the instructor.

9 Inspect the relief diaphragm.

10 Observe the explosion vent of the transformer and check the condition of relief diaphragm and record the observations in Table 2.

11 If it is cracked or broken replace it after isolating the primary supply to the transformer.

Table 2

Maintenance chart for daily maintenance of 3f oil cooled transformer

Date	Time	Oil level	Colour of Silicagel	Condition of relief diaphragam	Remarks action taken

— — — — —

Identify different types of HT/LT Cable

Objectives: At the end of this exercise you shall be able to
- **identify different types of HT/LT cables.**

Requirements

Tools/Instruments

- Combination Plier 200 mm - 1 No.
- Standard wire gauge - 1 No.
- Cable underground armoured/ unarmoured - as reqd
- Electrician's knife 100 mm - 1 No.
- Hacksaw adjustable 300mm with blade - 1 No.
- Aerial Bunched cable (armoured/ unarmoured) - as reqd.
- UG cable -as reqd.

Identifying high-tension (HT) and low-tension (LT) cables typically involves examining the voltage rating and physical characteristics of the cables. HT cables are designed to handle higher voltages, usually above 1 kV (1000 volts), while LT cables are used for lower voltages, generally upto 1Kv.

PROCEDURE

TASK 1: **Identify different types of HT/LT cables**

The instructor will arrange and provide the various types of cable(assorted different sizes) on the table and label them with alphabets and explain the trainees on, how to identify the types of insulation, conductors, size of conductor, single /multiple core and UG/AB cable

1 Take any one of from the table, note down its alphabet.

2 Measure the diameter of conductor of the cable and compare it to known HT and LT cable conductor diameters.

3 In some cases, cable manufacturers use colour coding to differentiate between HT and LT cables. Check the colour code used in manufacturer's guidelines.

4 Cables often have markings or labels indicating their voltage rating and usage. Look for these markings on the cable itself or its packaging.

5 Note the dia.and verify the type of insulation, voltage level, armour / armouring etc., Overhead / Underground and current rating. Then enter it in the table and verify the cable.

6 verify the specification of the cable by referring with the data book.

— — — — —

TASK 2: **Measuring the wire sizes by SWG in gauge number**

1 Skin the cute insulation of the cable

Exercise care to prevent from nicking

2 Clean the surface of the wire with a cotton cloth Remove insulate particles and any adhesive coating From the surface of the conductor

Do not use abrasives to clean the conductor, Use of abrasive material, reduces the size of the conductor.

3 Straighten the end of the conductor to be measured

Do not straighten conductors by directly using hand tools on them.

4 Insert the conductor in the slot of the wire gauge and determine its close fit (Fig 1)

5 Read the marking at the slot Fig 2 It gives the wire size in SWG The other side will give you the diameter of the wire in mm

6 Record the measured size in Table 1

Fig 1

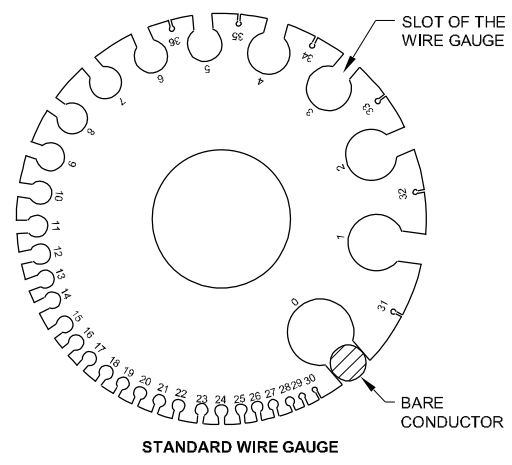


Fig 2

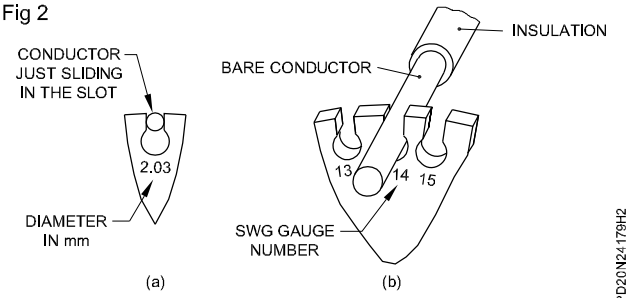
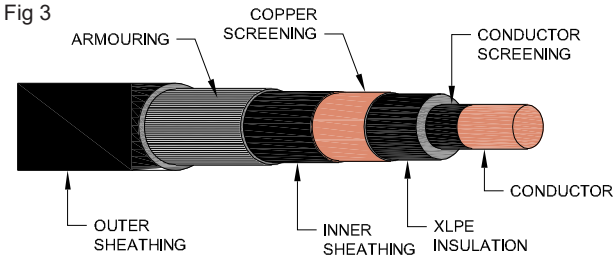


Fig 3



Cable	LT Cable	HT Cable
Rating	660V to 1100V	Above 3300V
Armouring	Armoured (Flat or Round) Unarmoured	Armoured (Flat or Round)
Insulation	PVC XLPE	XLPE
Conductor	Aluminium, Copper	Aluminium, Copper
No. of Cores	1 to 61 cores	1 Core, 3 Core
Application	Application revolving around 1.1kV range	HT cables are mainly used for power transmission and distribution of high voltage (> 1.1kV)

Table 1

Sl.No	**Alphabet**	**Type of insulation**	**Type of conductor material**	**Type of cable**		**Type of cors single/ 3/3 1/2**	**Core size in mm**	**UG/ABC**	**LT/HT**
				Armoured	**Unarmoured**				
1	A								
2	B								
3	C								
4	D								
5	E								

Table 2

Conversion table: SWG to inch/mm

No.	Inch	mm
7/0	0.500	12.7
6/0	0.464	11.38
5/0	0.432	10.92
4/0	0.400	10.16
3/0	0.372	9.44
2/0	0.348	8.83
0	0.324	8.23
1	0.300	7.62
2	0.276	7.01
3	0.252	6.40
4	0.234	5.89
5	0.212	5.38
6	0.192	4.88
7	0.176	4.47
8	0.160	4.06
9	0.144	3.66
10	0.128	3.25
11	0.116	2.95
12	0.104	2.64
13	0.092	2.34
14	0.080	2.03
15	0.072	1.83
16	0.064	1.63
17	0.056	1.42
18	0.048	1.22
19	0.040	1.02
20	0.036	0.91
21	0.032	0.81
22	0.028	0.71
23	0.024	0.61
24	0.022	0.56
25	0.020	0.51
26	0.018	0.46
27	0.0164	0.42
28	0.0148	0.38
29	0.0136	0.34
30	0.0124	0.31
31	0.0116	0.29
32	0.0108	0.27
33	0.0100	0.25
34	0.0092	0.23
35	0.0084	0.21
36	0.0076	0.19
37	0.0068	0.17
38	0.0060	0.15
39	0.0052	0.13
40	0.0048	0.12
41	0.0044	0.11
42	0.0040	0.10
43	0.0036	0.09
44	0.0032	0.08
45	0.0028	0.07
46	0.0024	0.06
47	0.0020	0.05
48	0.0016	0.04
49	0.0012	0.03
50	0.0010	0.02

— — — — —

Identify various parts of underground cable

Objectives: At the end of this exercise you shall be able to
- **identify the voltage grade of the cable**
- **skin the UG cable.**

Requirements

Tools/Instruments

- Insulated combination plier 200 mm - 1 No.
- DE Electrician's knife 100 mm - 1 No.
- Hacksaw adjustable 300 mm with blade - 1 No.
- Hand vice 50 mm jaw - 1 No.

Materials

- UG cable multicore eu/Al. 30 cm - 1 piece.
- Binding wire 16 SWG - as reqd.

PROCEDURE

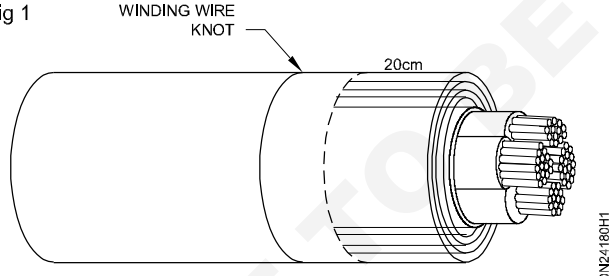
Paper insulated 3, 31/2 core cable may taken. This instructor has to demonstrate the steps for skinning and dressing of cables in this exercise.

1 Collect the UG cable piece and examine it for physical damage.

2 Bind the winding wire at 20 cm (20 m at one side) of the UG cable.

3 Mark 18 cm at one end near the binding wire knot from the end where skinning is to be done, as shown in Fig 1.

Fig 1



UG CABLE 3½ CORE

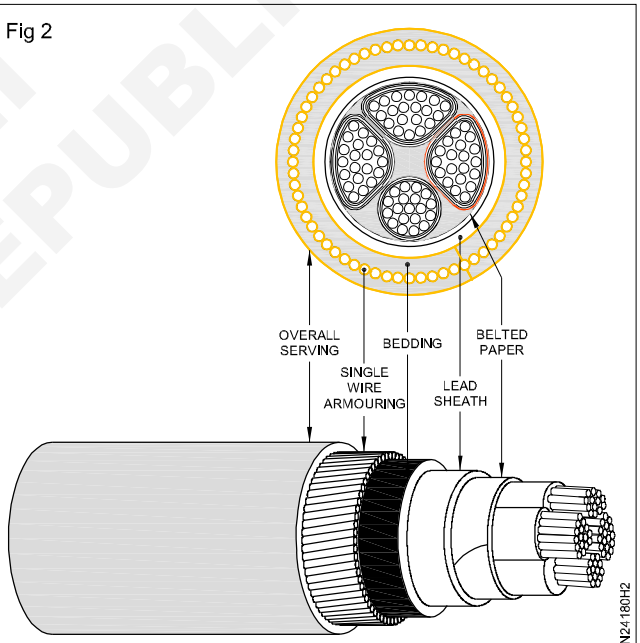
4 Cut the overall serving using the knife and remove the overall serving.

5 Mark 3 cm from the cutting edge and cut the single wire armouring using hacksaw.

6 Mark 3 cm from cutting edge and cut the bending using knife/hacksaw.

7 Repeat steps 2-6 to skin all other layers till it is visible as shown in Fig 2.

Fig 2



PAPER INSULATED 3 PHASE 3½ CORE CABLE

Carefully examine the skinned portion for any damage/excess cutting.

8 Dress the protruding parts of the cable using a knife for a better finish.

9 Get your work approved by your instructor.

Practice preparation of cables for termination and joining

Objectives: At the end of this exercise you shall be able to
- **prepare cables for termination and joining.**

Requirements

Tools/Instruments

• Measurement tape	- 1 No.
• Knife	- 1 No.
• Mini handsaw	- 1 No.
• Nose plier	- 1 No.
• Combination plier	- 1 No.
• Screwdriver	- 1 No.
• Round file	- 1 No.
• Marking pen	- 1 No.
• Pipe cutter	- 1 No.
• Rachet cutter	- 1 No.
• Semi conductor peeling machine	- 1 No.

Materials

• Xlpe cable 3x300sq	- as reqd.
• Insulation tap	- 1 No.
• Halloxide cloth	- 1 No.
• Toin	- 1 No.
• Cleaning tissue	- 1 No.
• Cleaning liquid	- 1 No.
• Silicon greese	- 1 No.
• Cu wire	- 10 m.

PROCEDURE

1 Read the leaflet carefully before starting the work.

2 To prepare the cable end, working area is thoroughly cleaned and dried and kept in this state throughout the installation procedure.

3 Cover the section sheath.

4 Mark the required length (measurement calculated as per the leaflet in the manufacturer's kit)

5 Cut and peel the outer sheath

6 Remove armouring accurately.

7 Remove the outer sheath about 5 cm from peeling end.

8 Mark 2cm from armouring portion, cut and remove the remaining portion of sheath and strip,

9 Place and Mark the stress control tube.

10 Wind Cu wire on Cu sheath as required length and remove the remaining portion of the Cu sheath.

11 Mark 5 cm from Cu sheath on both sides, then remove the portion

12 Clean using halloxide cloth

13 Cut the required portion of XLPE at both ends using Toin/pipe cutter (ie 1/2 of crimping socket)

14 Cleaning conductor using cleaning liquid and tissue.

15 Take cable leg, mark on semiconductor from cable end, remove it using peeling machine, positioned the leg on conductor and crimp the socket one side. (applicable while termination.

16 Bind the insulation tape through sockets with 1cm outer sides.

17 Apply Cu mesh on jointed portion on each side upto Cu sheath.

18 Wind the mesh using Cu lead.

19 Fix the braided Cu on each armouring portion.

20 Round polyethelene diaphram on it.

21 Wrap GI mesh on bare cable portion and sealing using mastic tape on each ends.

The cable being jointed or terminated forms a vital and integral part of the completed cable joint or cable termination. Do the work accurately and skillfully.

Techniques involved in the preparation of cables are quite different for paper cables and polymeric cables.

Compared with paper cables, polymeric cables appear easy to work with. They have no oily impregnating compound, are generally lighter in weight and more flexible. Many special tools are available to assist the correct preparation of polymeric cables for jointing and terminating.

The cable outer sheath will probably have metallic components immediately under it.Use an appropriate sheath removal tool rather than an unguarded knife.

Removal of the black conductive semicon screen layer covering the insulation is a critically important stage in the preparation of polymeric cables. Its thickness is generally between 0.3 mm and 0.6 mm and there are of two types

1 'peelable' (non-bonded) screens which can be peeled away from the insulation to leave a smooth clean surface, and

2 'bonded' screens which are firmly bonded to the insulation.

NEVER use an unguarded knife. This includes broken glass and any other object with a sharp unguarded edge

If an unguarded knife is used, there is a very significant risk of cutting into the insulation at the screen edge.

For peelable screens, the technique is to make spiral or longitudinal cuts into the screen to a depth less than its thickness.

Some MV accessory manufacturers and users recommend removing a ring of peelable conductive screen material at the screen edge position using a round file. This is done before removing the rest of the screen layer. The file is used carefully and uniformly.

For bonded screens, many special tools are available. After setting up the tool according to the diameter over the screen and the screen depth, the tool is moved in a spiral motion from the cable end to the screen cut position.

In order to remove enough but not too much insulation, a practical guide is to set the removal tool so that the strip being removed shows 2/3 black screen and 1/3 insulation across its width

After cutting the core (conductor and insulation) to length, removal of the insulation to fit the connector will be made easier using the appropriate special tool.

Some accessories, especially for higher voltage cables, may require that the edge of the insulation is chamfered (tapered)

Before installing components of the joint or termination, the prepared cable core should be cleaned to remove any dirt or other contaminants. This should be done using clean cloths and a recommended cleaning agent. Wiping of the insulation should always be done towards the conductive screen. A cloth that has been wiped over the screen should be discarded and replaced with a clean one. Similarly, the connector should be wiped without allowing the wiping cloth to contact the insulation surface.

Some older polymeric cables do not have an extruded conductive screen. The screen in these cables will probably be a black conductive graphite-based 'paint' covered by a conductive fabric tape. To prepare a screen edge, the tape is unwound and fixed at an appropriate position back from the screen edge position. The exposed conductive paint is then masked with tape and the conductive paint is removed to the screen edge position using a recommended solvent.

Paper cables are no longer installed. Installers will probably only have to work with them when making transition joints to newly-installed polymeric cable. Installers who are not familiar with paper cables should take special training before working with them

Paper is a natural material and suffers from ageing as a result of long term exposure to raised temperature during service. The most damaging result of ageing is embrittlement of the paper tapes, making them likely to crack or break when the cable core is moved. Broken insulating papers will significantly weaken the electric strength of the insulation as a whole. The following is best practice when handling paper cables.

Do not bend the cable any more than is strictly necessary. Remember that the paper insulation will be more brittle than when the cable was made.

Remove the metallic sheath only when necessary. Once the paper insulation is exposed it will absorb moisture and become electrically weaker. Beyond this point installation work should proceed without delay.

If possible, do a moisture test on the paper insulation to prove that it has not been exposed should environment. If the insulation proves to be wet, installation work should not proceed.

With 3-core cables, support the cable crutch when separating and setting the cores into position.

Support the crutch with a firm hand or wrap it with strong cloth tape.

Fig 1

Fig 2

Fig 3

Fig 4

Fig 5

Fig 6

Fig 7

Fig 8

Fig 9

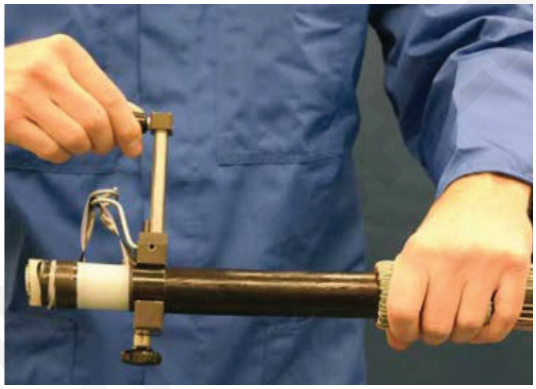


Fig 10

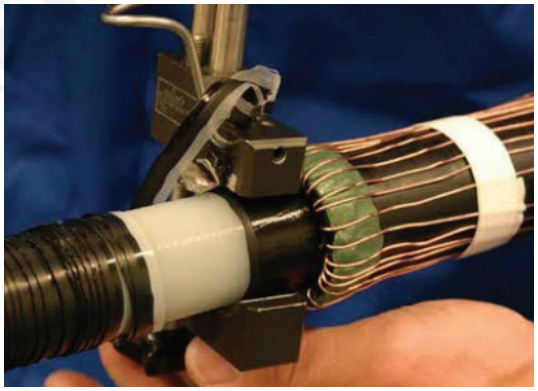


Fig 11

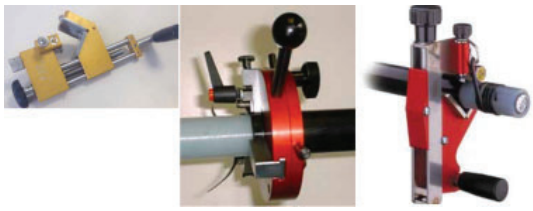


Fig 12

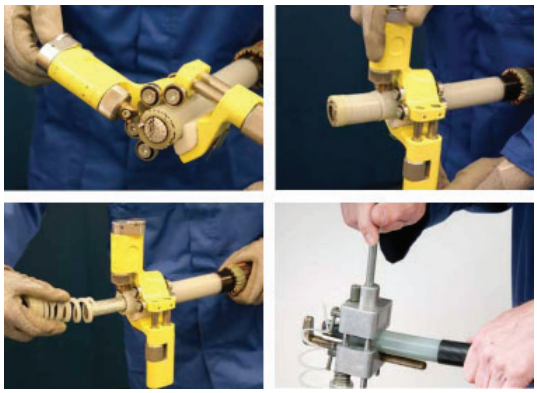


Fig 13

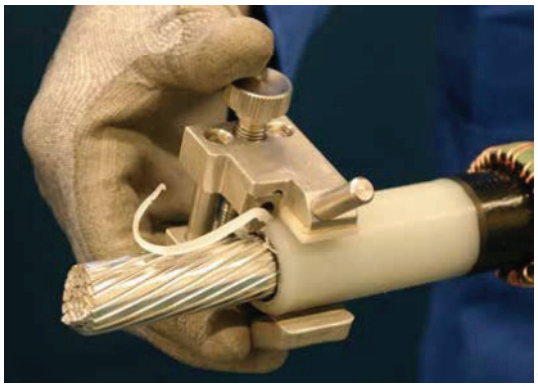


Fig 14

Fig 15

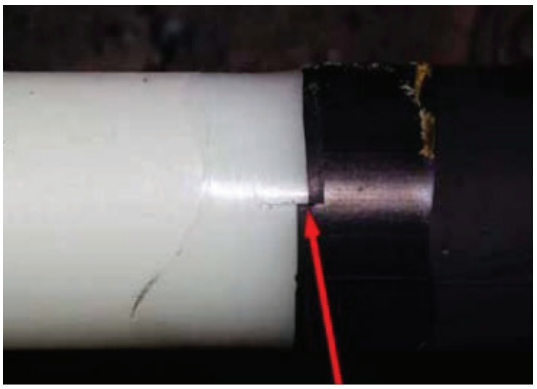


Fig 16

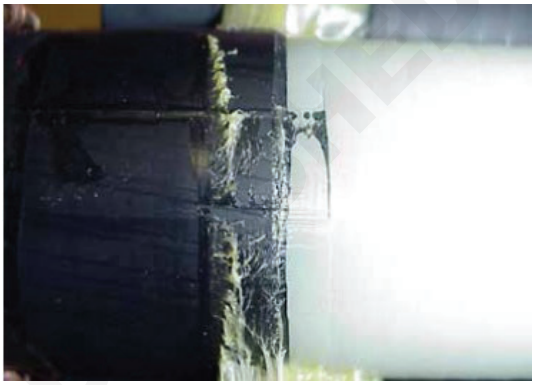


Fig 17

Fig 18

Demonstrate termination kits and practice on terminations of LT/HT cables

Objectives: At the end of this exercise you shall be able to
- **identify termination kits**
- **make terminations of Cables.**

Requirements

Tools/Instruments

• Measurement tape	- 1 No.
• Knife	- 1 No.
• Mini handsaw	- 1 No.
• Nose plier	- 1 No.
• Combination plier	- 1 No.
• Screwdriver	- 1 No.
• Round file	- 1 No.
• Marking pen	- 1 No.
• Pipe cutter	- 1 No.
• Rachet cutter	- 1 No.
• Semi conductor peeling machine	- 1 No.
• Gas blow lamp (.3mm)	- 1 No.
• Crimping tool	- 1 No.
• Stress control tube	- 1 No.
• Cu mesh	- 1 No.
• Breakout	- 1 No.
• Mastic tape	- 1 No.
• Anti tracking tube	- 1 No.
• Insulation tape	- 1 No.
• Toin	- 1 No.
• Halloxide shower	- 1 No.
• Cleaning tissue	- 1 No.
• Cleaning liquid	- 1 No.
• Silicon greese	- 1 No.
• Cu belt	- reqd length.
• Tinned Cu wire	- as reqd.
• Back up clamp	- 2 Nos.
• Al Lugs	- 3 Nos.

Materials

• Xlpe cable 3x300sq mm	- as reqd.
• Booting	- 1 No.

PROCEDURE

1 Read the leaflet carefully before starting the work.

2 Mark the outer sheath.

3 Peel the outer sheath.

4 Cut Cu sheath 3cm approx.

5 Bind insulation tape on two sides

6 Cut semi conductor about 2cm

7 Peel the paper insulation,

8 Polish semi conductor material using halloxide cloth/ amari paper

9 Connect Cu earth belt (remove insulation tape) on Cu sheath and bind on Cu belt using tinned wire.

10 Apply silicon grease on y mastic tape and bind red mastic tape on it.

11 Provide stress control tube (bind mastic tape two side) and shrink the tube using blow lamp.

12 Peel the semi conductor material and crimp socket on it.

13 Remove the dust or water contents in area and bind red mastic tape on socket.

14 Apply silicon grease on leg.

Fig 1

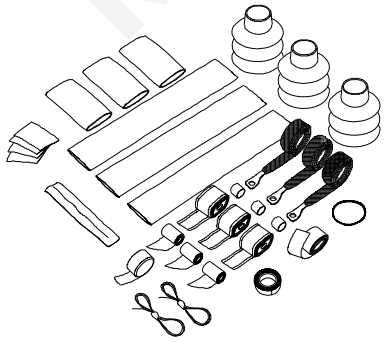


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Fig 2

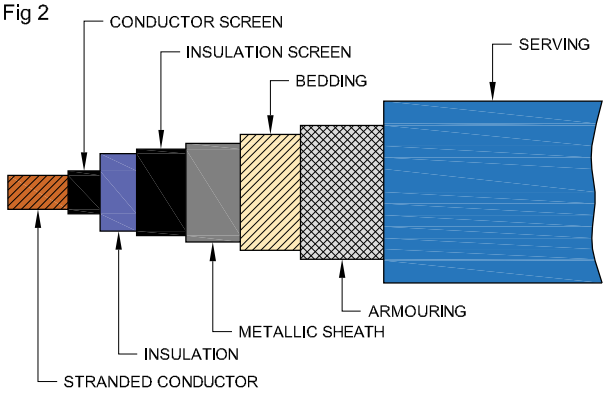

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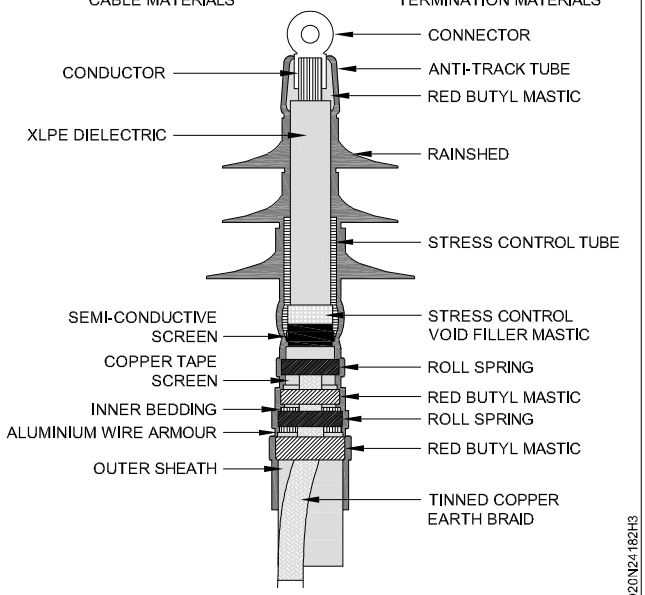
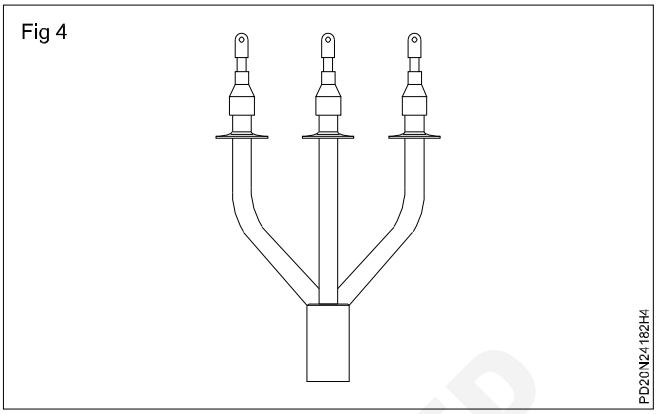
Fig 3



15 Positioned anti tracking tube and shrink it using blow lamp (Before positioned remove paper inside the tube)

16 Fit the skirt(15cm centered and 6cm apart from one.

Fig 4



Make straight joint of different types of underground cable

Objectives: At the end of this exercise you shall be able to
- **make straight joint of underground cables.**

Requirements

Tools/Instruments

- Measurement tape - 1 No.
- Knife - 1 No.
- Mini handsaw - 1 No.
- Nose plier - 1 No.
- Combination plier - 1 No.
- Screwdriver - 1 No.
- Round file - 1 No.
- Marking pen - 1 No.
- Pipe cutter - 1 No.
- Rachet cutter - 1 No.
- Semi conductor peeling machine - 1 No.
- Gas blow lamp (3mm) - 1 No.
- Crimping tool - 1 No.

Materials

- Xlpe cable 3x300sq - as reqd.
- Booting - 1 No.
- Stress control tube - 1 No.
- Cu mesh - 1 No.
- Thimble - 1 No.
- Mastic tape - 1 No.
- Sealant - 1 No.
- Insulation tape - 1 No.
- Toin - 1 No.
- Halloxide shower - 1 No.
- Cleaning tissue - 1 No.
- Cleaning liquid - 1 No.
- Silicon greese - 1 No.
- Cu wire - as reqd.
- Jubilee clamp - 2 Nos.
- Braided cu - reqd length.
- GI mesh - reqd length.
- Back up clamp - 2 No.

PROCEDURE

1 Read the leaflet carefully before starting the work.

2 Mark the required length (approx. 75cm & 45 cm at each side of the cables)

3 Cut and peel the outer sheath

4 Remove armouring accurately,

5 Remove the outer sheath about 5cm from peeling end, and place Braided Cu under the armouring.

6 Provide back up clamp.

7 Tighten the jubilee clamp on each side of the cable.

8 Mark 2cm from armouring portion, cut and remove the remaining portion of sheath and strip

9 Place and Mark the stress controll tube (36cm) ie. 36/2+2 cm extra= 20cm.

10 Wind Cu wire on Cu sheath as required length and remove the remaining portion of the Cu sheath

11 Mark 5cm from Cu sheath on both sides, then remove the portion

12 Clean using halloxide cloth

13 Cut the required portion of XLPE at both ends using toin/pipe cutter (ie 1/2 of crimping socket)

14 Cleaning conductor using cleaning liquid and tissue.

15 Provide boot through cable end on each side.

16 Provide stress control tube on single cores on each side of the cable.

17 Take cable leg, remove the cap inside it, positioned the leg on core and crimp the socket one side.

18 Positioned the cable leg for grouping two sides, pull the core inside the socket and crimp it accurately

19 Bind the insulation tape through sockets with 1cm outer sides

20 Positioned the stress control tubes, shrink using gas blow lamp(centre to both sides)

21 Positioned protection tube and shrink using blow lamp

22 Positioned double protection tube and shrink using blow lamp.

23 Apply Cu mesh on jointed portion on each side upto Cu sheath

24 Wind the mesh using Cu lead.

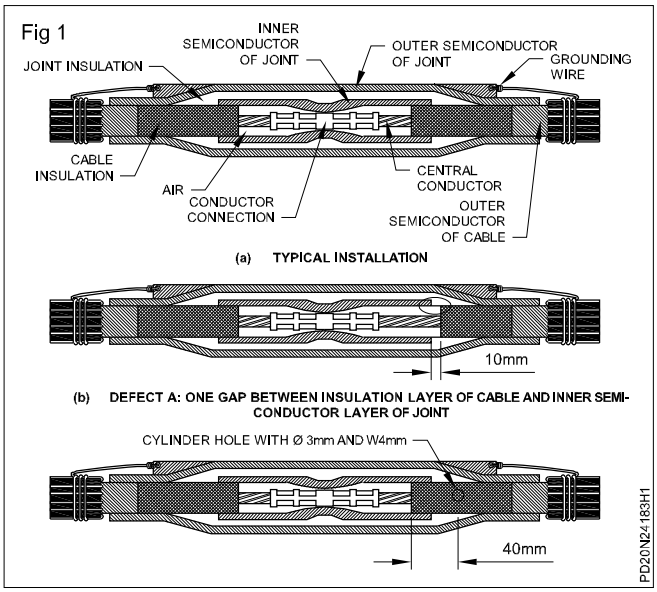
25 Fix the braided Cu on each armouring portion.

26 Round polyethelene diaphram on it.

27 Wrap GI mesh on bare cable portion and sealing using mastic tape on each ends

28 Mark 20cm from each centre of the cable. (Fig 1)

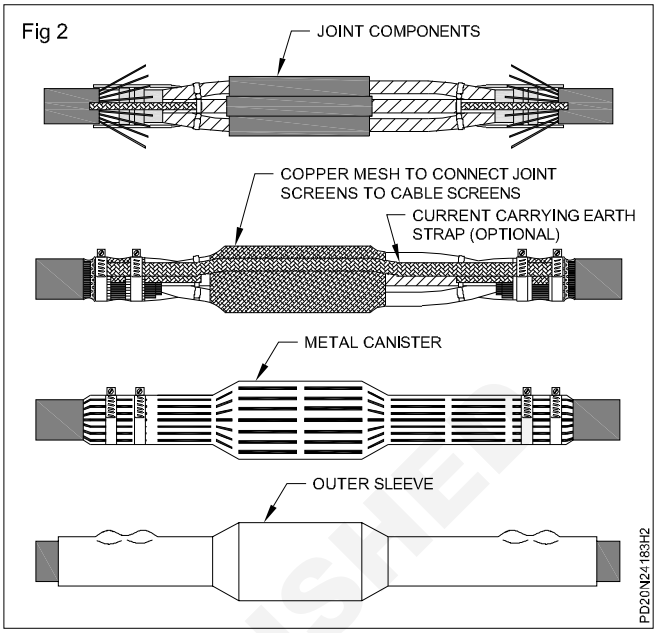
Fig 1



29 Round sealing mastic tape of both ends to centre.

30 Positioned booting tube and shrink the tube using blow lamp. (Fig 2)

Fig 2



Carryout high voltage (hipot) test

Objectives: At the end of this exercise you shall be able to
- **carryout high voltage test of UG cable.**

Requirements

Tools/Instruments

• Test kit	- 1 No.	• PPE	- 1 No.
• 220 v A.C supply	- 1 No.		

PROCEDURE

Only electrically qualified workers may perform this testing.

1 Open circuit breakers or switches to isolate the circuit or Cable that will be hi-pot tested.

2 Discharge the residual current in cable by discharge rod.

3 Confirm that all equipment or Cable that is not to be tested is isolated from the circuit under test

4 The limited approach boundary for this hi-pot procedure at 1000 volts is 5 ft. (1.53m) so place barriers around the terminations of cables and uipment under test to prevent unqualified persons from crossing this boundary.

5 Connect the ground lead of the HIPOT Tester to a suitable building ground or grounding electrode conductor.

6 Attach the high voltage lead to one of the isolated circuit phase conductors.

7 Switch on the HIPOT Tester. Set the meter to 1000 Volts or pre decide DC Voltage. Push the “Test” button on the meter and after one minute observe the resistance reading.

8 Record the reading for reference.

9 At the end of the one minute test, switch the HIPOT Tester from the high potential test mode to the voltage measuring mode to confirm that the circuit phase conductor and voltage of HIPOT Tester are now reading zero volts.

10 Repeat this test procedure for all circuit phase conductors testing each phase to ground and each phase to each phase

11 When testing is completed disconnect the HIPOT Tester from the circuits under test and confirm that the circuits are dear to be re-connected and re-energized.

12 To PASS the unit or Cable under Test must be exposed to a minimum Stress of pre decide Voltage for 1 minute without any Indication of Breakdown. For Equipments with total area less than 0.1 m2, the insulation resistance shall not be less than 400 MO. For Equipment with total area larger than 0.1 m2 the measured insulation resistance times the area of the module shall not be less than 40 $M\Omega\text{-}m^2$

During a HIPOT Test. There may be at some risk so to minimize risk of injury from electrical shock make sure HIPOT equipment follows these guidelines:

The total charge you can receive in a shock should not exceed 45 uC.

The total hipot energy should not exceed 350 mJ. The total current should not exceed 5 mA peak (3.5 mA rms

The fault current should not stay on longer than 10 ms.

If the tester doesn’t meet these requirements then make sure it has a safety interlock system that guarantees you cannot contact the cable while it is being hipot tested.

For Cable:

Verify the correct operation of the safety circuits in the equipment every time you calibrate it.

Don’t touch the cable during hipot testing.

Allow the hipot testing to complete before removing the cable.

Wear insulating gloves.

Don’t allow children to use the equipment.

If you have any electronic implants then don’t use the equipment.

Fig 1

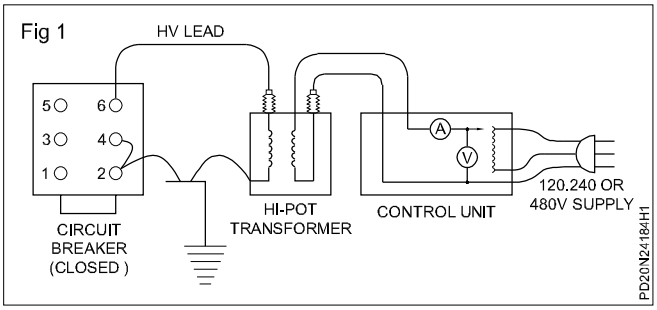


Fig 2

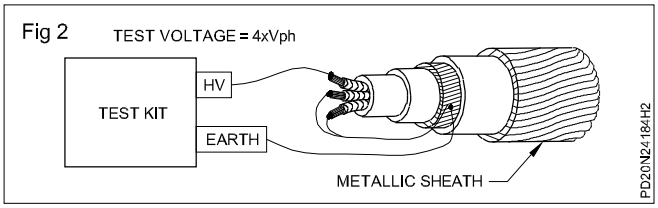
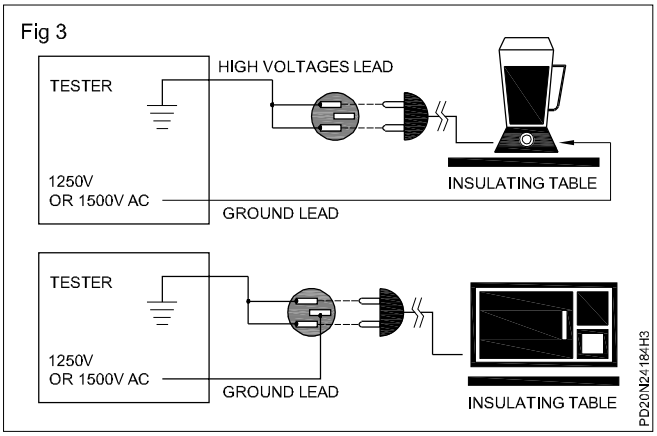


Fig 3



Practice laying of HT/LT cables in raceways and trenches

Objectives: At the end of this exercise you shall be able to
- **laying of HTALT UG cables in raceways and trenches.**

Requirements

Tools/Instruments

• Man power	- as reqd.	• Rollers(straight/pipa/comer)	- 1 No.
• Tools and Equipments	- 1 Set.	• cable pulling shocks	- 1 No.
• Winch machine	- 1 No.	• Safety gloves	- 1 No.
• cable trolly	- 1 No.	• Flag man	- 1 No.
• Crane	- 1 No.	• Electrician's kit	- 1 No.

PROCEDURE

1 Before provide trench, clearance standard kept in mind.

2 Dig the trench as per the table 283,

3 Then the trench is covered with a 10cm thick layer of dry soft sand.

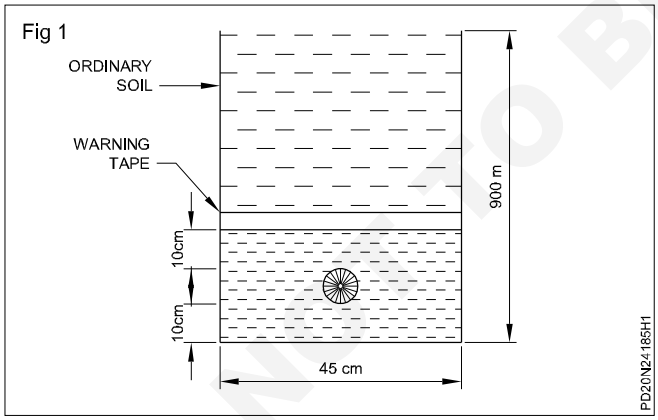
4 Provide the which machine on one side and cable drum on the other side of the trench.

5 Raise the drum on ground level as the required height using crane.

6 Cable pulling shocks is provide on cable end and tight the shocks on cable using cotton cloth ribbon.

7 Start the winch machine and draw the steel wire towards the cable end help of man power.

Fig 1



8 Place steel wire on roller.

9 Connect the steel wire on cable shocks end hooks.

10 After giving sign from flagman, operate the winch machine reverse direction and laid the cable into the trench through rollers.

11 After draw the cable remove the rollers.

12 Place the cable on trench and fill with dry soft sand 10cm height.

13 Provide the warning tape(concrete half round brick/ bricks/tiles)

14 Back filling ordinary soil up to machine ground level.

When multiple cables are to be laid in the same trench horizontal/vertical spacing of about 30cm is provided.

Fig 1

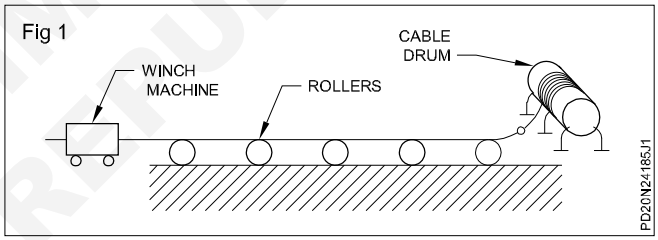


Table 1

Type of Cable	Clearance
PC to Control cable	0.2 m
PC to Comm. cable	0.3 m

Standard on Power IS 1255

Table 2

Voltage Level	Depth
33 KV	1.5 m
22 KV to 33 KV	1.05 m
3.3 to 11 KV	0.9 m
Low Voltage & Control Cable	0.75 m

Table 3

Cable	Width
Single Cable	45 cm
Multiple Cable	45 + 30cm of each cable

Demonstrate and identify various cable glands

Objectives: At the end of this exercise you shall be able to
- **identify the various cable glands.**

Requirements

Tools/Instruments

- Different types of cable glands - 1 No each.
- A4 paper - 1 No.
- Per/Pencil - 1 No.

Cable glands are connectors used to seal the ends of cables and secure them to plugs,terminals enclosures or electrical equipments of various kinds. They can protect sensitive electrical wiring from moisture contaminations.corrosion and even flammable gas.Commonly they are threaded cables glands, compression cable gland and armoured cable glands. Cable glands have a threaded connection that allows them to be screwed on to the equipments or enclosure. They are available in different thread sizes for various cable diameters.Compression glands use a compression mechanism to secure the cable in place. They provide a light seal and are commonly used in hazardous or harsh environments Armoured glands are specially designed in for use of armoured cables. They are also classified into single compression, double compression and flexible hose.Compression cables are available in A1/A2 type also A1/A2 glands are weather proof glands and can be used in corrosion environment Flame proof A2F cable glands use in hazardous environment. Metal glands unarmoured A2 type design for general purpose used with XLPE and PVC cables upto 78 mm dia. is available A1/A2 industrial cable glands used with unarmoured elastomer and plastic insulated cables in indoor and outdoor to provide sealing on cable outer sheet

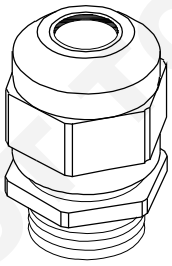
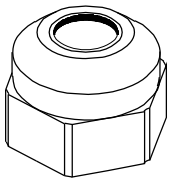
PROCEDURE

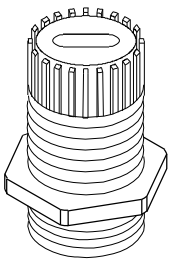
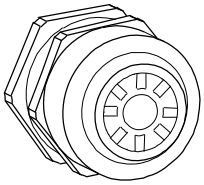
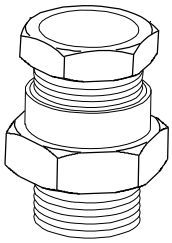
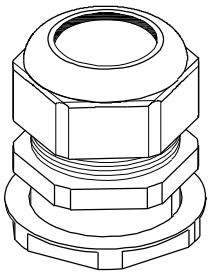
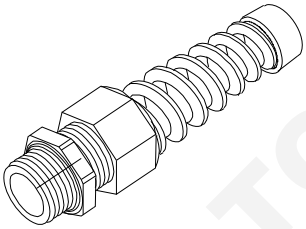
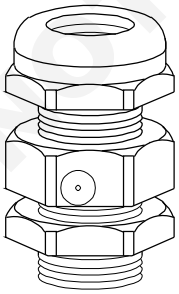
1 Collect various types of cable glands and put it on workbench

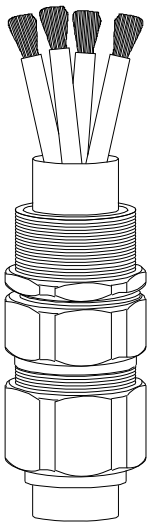
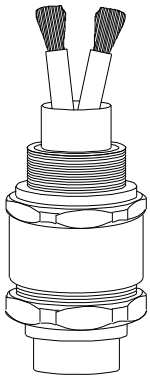
2 Understand the different types of cable glands from table 2 and above mentioned

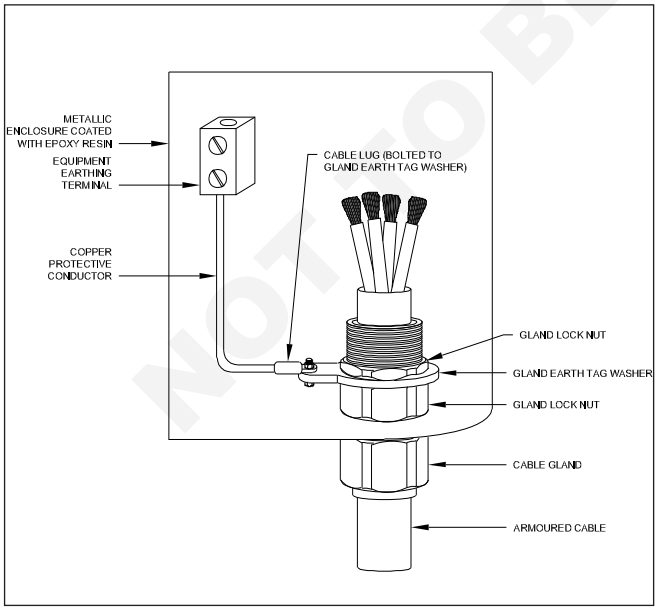
3 Check the cable glands and note its diameter and its type(armoured unarmoured make of glands as pvc/ stainless/brass/heat tracing black)

4 Identity and note down the cable glands standard as in figure 1.

1		
2		

3		
4		
5		
6		
7		
8		

9		
10		



Practice passing of cable entry plate for standard cables without connectors, upto IP 68 rated protection

Objectives: At the end of this exercise you shall be able to
- **practice passing of cable entry plate for standard cables without connectors, upto IP 68 rated protection.**

Requirements

Tools/Instruments

• Drill machine	- 1 No.	• safety gloves	- 1 No.
• Cable glands	- as reqd.	• Waterproof sealant	- 1 No.
• Cable entry plates	- as reqd.	• Screws(various sizes)	- 1 No.
• Electrician's kit	- 1 No.		

PROCEDURE

1 Choose the Right Entry Plate: Select an IP68-rated cable entry plate suitable for the number and diameter of cables you're passing through.

2 Gather the necessary tools such as a screwdriver, sealant, and appropriate cable glands if required Make sure the area around the entry point is clean and free of debris.

3 Decide on the entry point on the enclosure where you want to pass the cables

4 If the enclosure doesn't have a pre-made hole for the entry plate, carefully drill a hole of the appropriate size to accommodate the entry plate.

5 Insert the Entry Plate: Place the cable entry plate over the drilled hole. Ensure that any gaskets or seals provided with the entry plate are correctly positioned to maintain the IP68 rating.

6 Insert the standard cables through the holes in the cable entry plate without damage cables insulation.

7 Using cable glands, lighten them around each cable to create a secure seal.

8 Apply a suitable waterproof sealant or grommet around the cables where they pass through the entry plate. This helps to maintain the IP68 protection and prevent water or dust ingress.

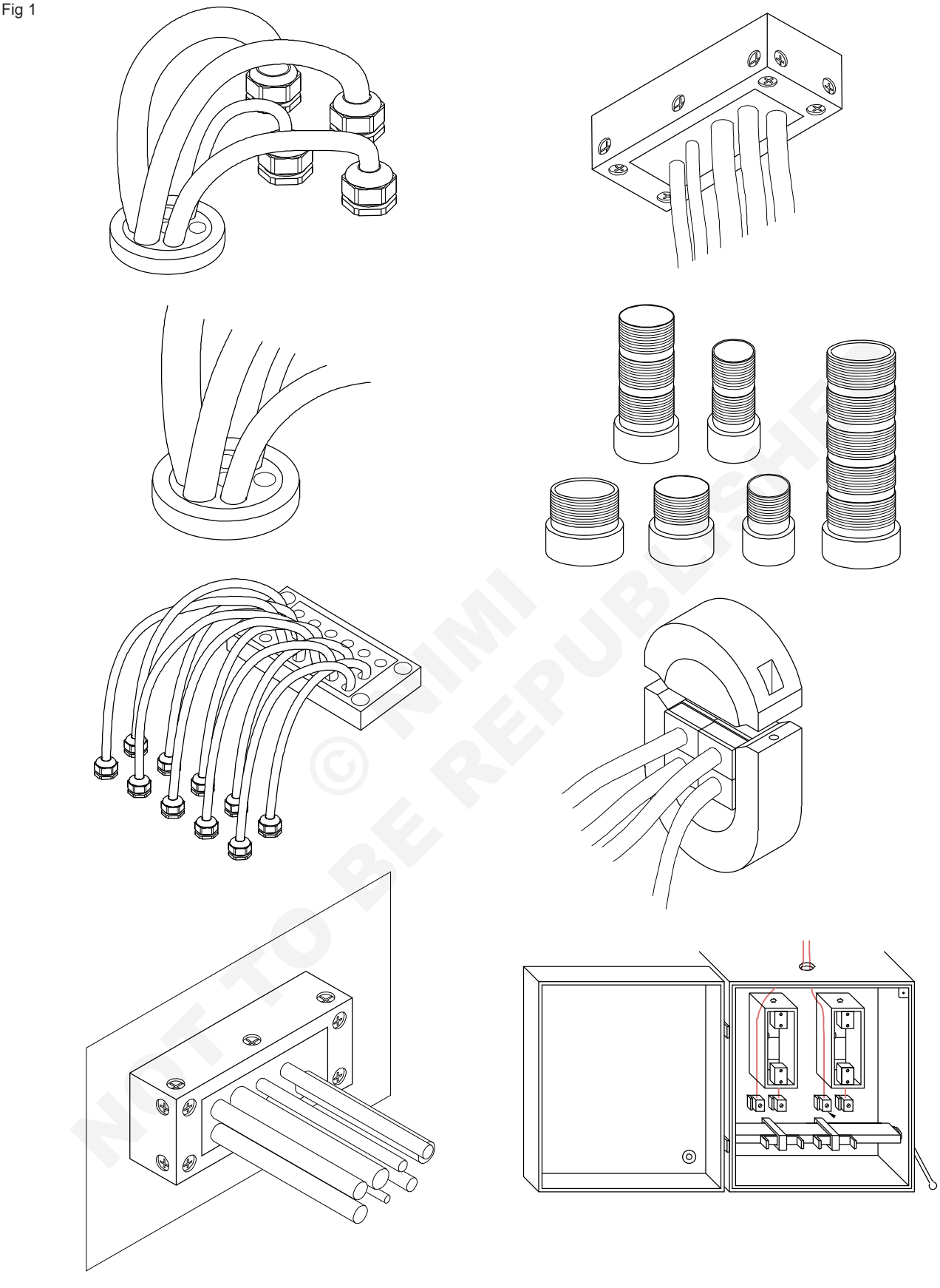
9 Securely fasten the cable entry plate to the enclosure using the provided screws or fasteners.

10 check that all cables are properly positioned and secured. Verify that the sealant is applied evenly and covers any gaps.

11 Once the entry plate is installed, you can conduct a water or dust ingress test to confirm that the IP68 protection level is maintained.

Remember to follow the manufacturer's instructions and guidelines for both the cable entry plate and any additional components you're using.(Fig 1)

Fig 1



PD20N2-187T1

Practice split cable entry for pre-terminated cables, upto 65 rated protection

Objectives: At the end of this exercise you shall be able to
- **practice split cable entry for pre-terminated cables, upto IP 65 rated protection.**

Requirements

Tools/Instruments

• Drill machine	- 1 No.	• Safety gloves	- 1 No.
• Cable glands	- as reqd.	• Waterproof sealant	- as reqd.
• Cable entry plater IP65 rated	- as reqd.	• Screws (Different sizes)	- as reqd.
• Electrician's knife	- 1 No.		

PROCEDURE

To achieve IP65-rated protection for multiple pre-terminated cables, you can use a cable entry system designed for this purpose. These systems typically consist of cable glands, grommets, or sealing plates that provide a secure and watertight seal around the cables as they enter an enclosure or housing.

1 Choose a cable entry system that suits the number and size of your pre-terminated cables. Look for IP65-rated cable glands or entry plates.

2 Ensure that the enclosure or housing where the cables will enter is clean and free from debris. This will help in creating an effective seal.

3 Mark the locations where the cables will enter the enclosure. These points should be adequately spaced to prevent crowding

4 Install the Cable Entry System:

For each cable, pass it through a cable gland designed for its size. The cable gland will have a scatting mechanism that tightens around the cable, providing a watertight seal. Grommets or Sealing Plates: If using a grommet-based system, insert the pre-terminated cables through the appropriate grommet holes. Some grommet systems allow for easy addition or removal of cables.

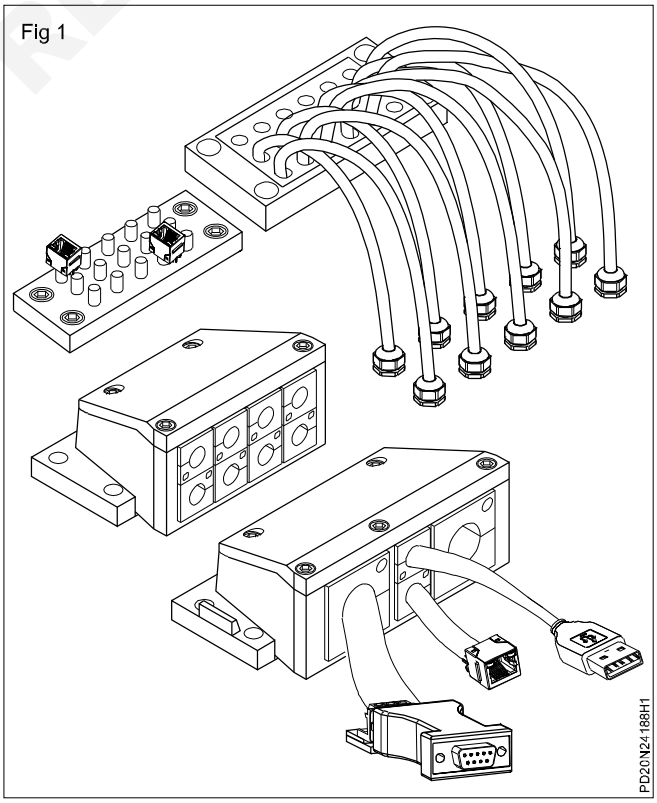
5 Depending on the cable entry system, tighten the sealing mechanisms to secure the cables in place. This will prevent water, dust, and other contaminants from entering the enclosure.

6 Once the cables are installed, inspect the assembly to ensure that the cable entry system is property sealed. Look for any gaps or areas that might compromise the IP65 rating.

7 Perform a water or dust ingress test to confirm that the IP65 protection is effective. This might involve spraying water at various pressures onto the cable entry points and checking for any signs of moisture inside the enclosure.(Fig 1)

Remember to follow the manufacturer's instructions and guidelines for the specific cable entry system you're using Each system might have its own unique steps and requirements. If you're unsure or unfamiliar with the process, it's advisable to consult with professionals who specialize in cable management and enclosure sealing.

Fig 1



Practice cable entry on a switch cabinet wall

Objectives: At the end of this exercise you shall be able to
- **do cable entry on cabinet wall.**

Requirements

Tools/Instruments

• Drilling machine	- 1 No.	• Gromets/cable entry plates	- 1 No.
• Deburring tools	- 1 No.	• Gasket sealing components	- as reqd.
		• Cable glands	- as reqd.

PROCEDURE

Safety Precautions: Before you begin, ensure that all power sources to the switch cabinet are turned off and that you're wearing appropriate personal protective equipment.

1 **Select Entry Point:** Determine the optimal location on the switch cabinet wall where you want to bring in the cables. Consider factors like cable length, accessibility, and cable management.

2 **Mark Entry Points:** Mark the entry points on the wall, ensuring that they are aligned with the internal components of the cabinet and any cable management systems you plan to use.

3 **Drilling:** Use an appropriate drill bit to create holes at marked entry points.

3 **Deburring:** After drilling, use a deburring tool to smooth the edges of the holes for prevents cable damage and easier to feed the cables through.

4 **Grommets or Cable Entry Plates:** Depending on the design of the switch cabinet, install grommets or cable entry plates around the drilled holes, help protect the cables from sharp edges and provide strain relief.

5 **Prepare Cables:** If necessary, strip the outer insulation of the cables to expose the individual wires. Also, attach any connectors or terminations needed for the specific application.

6 **Feed Cables Through:** Carefully insert the cables through the holes from the outside of the cabinet. You might need assistance inside the cabinet to guide the cables to the appropriate internal locations.

7 **Secure Cables:** Inside the cabinet to keep the cables organized and prevent tangling. This might include cable ties. clips, or cable management bars.

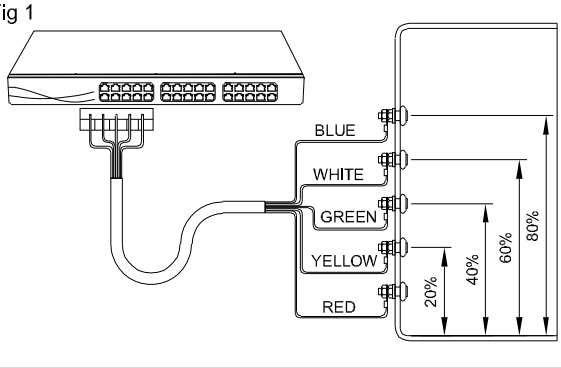
8 **Sealing:** To seal the holes around the cables using sealing compounds or gaskets.

9 **Test and Verify:** Once the cables are in place, conduct tests to ensure that they are functioning as expected and haven't been damaged during the installation process.

10 **Final Check:** Inspect the cable entry points, both inside and outside the cabinet, to make sure they are secure, properly sealed, and free from any sharp edges that could damage the cables.

Remember to follow any specific guidelines provided by the switch cabinet manufacturer, as the steps might vary based on the cabinet's design and intended use.

Fig 1



Demonstrate Bonding and grounding of raceways, cable assembly and panels

Objectives: At the end of this exercise you shall be able to
- **understand the method of bonding and grounding of raceways, cablo assembly and panels.**

Requirements			
• PPE Kit	- 1 No.	• Tag	- 1 No.
• Lock	- 1 No.	• Earth Tester	- 1 No.

PROCEDURE

1 Before working s appropriate personal protective equipment (PPE) and ensure the area is safe to work in.

2 Carefully watch the demonstration.

3 Inspect all raceways, cable assemblies, and panels for any damage, corrosion, or defects. Replace any damaged components.

4 Tum off the power to the circuits you'll be working on, and lock/tag the equipment to prevent accidental re energization.

5 Install bonding jumpers to connect metal raceways and cable trays, ensuring electrical continuity.

6 Bond grounding electrode conductors to the main grounding bus in panels.

7 Connect the grounding electrode conductor to the grounding electrode (e.g. ground rod).

8 Ensure proper connection to building steel if applicable.

9 Connect the grounding electrode conductor to the main grounding bus in each panel.

10 Bond the metal enclosures of panels to the grounding system using appropriate jumper

11 Bond the metal raceways and cable trays to the grounding system using grounding conductors.

12 For cable assemblies, connect the grounding conductor to the metal armour or sheath of the cables.

13 Bond all metallic equipment, such as junction boxes and enclosures, to the grounding system using grounding conductors.

14 Ensure a continuous electrical path between all metal components.

15 Use appropriate testers or instruments to ensure proper grounding and bonding continuity.

16 Perform resistance testing to verify low resistance values in the grounding system.

17 Label all grounded and bonded components for identification.

18 Maintain clear documentation of the grounding and bonding system layout for future reference.

19 Once all bonding and grounding is verified and completed, restore power to the circuits following established safety procedures.

20 Conduct a final inspection to ensure that all bonding and grounding measures are correctly implemented.

Remember that electrical codes and regulations may vary based on location and application. Always follow local codes, standards, and guidelines when performing bonding and grounding procedure

Cable tray may be used as the Equipment Grounding Conductor (EGC) in any installation where qualified persons will service the installed cable tray system. There is no restriction as to where the cable tray system is installed.

Practices for grounding and bonding of cable trays (photo credit: whereis.com)

The metal in cable trays may be used as the EGC as per the limitations of table 392.60(A). All metallic cable trays shall be grounded as required in Article 250.96 regardless of whether or not the cable tray is being used as an equipment grounding conductor (EGC).

The EGC is the most important conductor in an electrical system as its function is electrical safety.

There are three wiring options for providing an EGC in a cable tray wiring system:

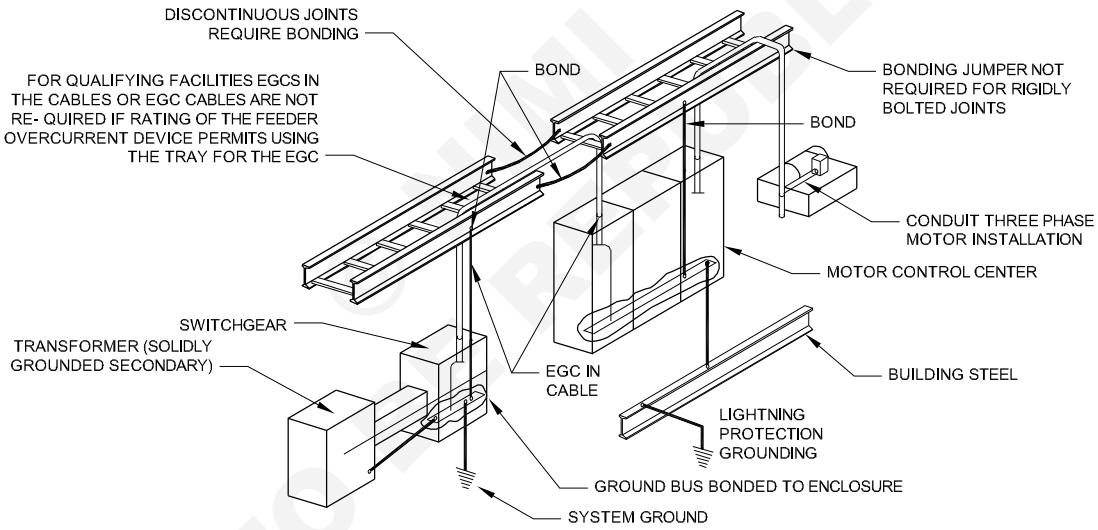
1 An EGC conductor in or on the cable tray.

2 Each multi-conductor cable with its individual EGC conductor.

3 The cable tray itself is used as the EGC in qualifying facilities.(Fig 1)

Fig 1

Fig 2



Test underground cables for faults, and remove the fault

Objectives: At the end of this exercise you shall be able to
- **locate open circuit faults in the cable**
- **locate short circuit faults in the cable**
- **locate the ground fault in the cable and rectify the fault.**

Requirements

Tools/Instruments

- Combination plier 200 mm - 1 No.
- Connector Screw driver 100 mm - 1 No.
- Screw driver 200 mm with blade of 4 mm width - 1 No.
- D.E electrician's knife 100 mm - 1 No.
- Megger 500V - 1 No.

Tools/Instruments

- Wheatstone bridge - 1 No.

Tools/Instruments

- Connecting Prod for Megger - 1 Set.
- Connecting Prod for Wheatstone bridge - 1 Set.
- Connecting Cables (flexible, uniform, cross sectional area) - as reqd.

PROCEDURE

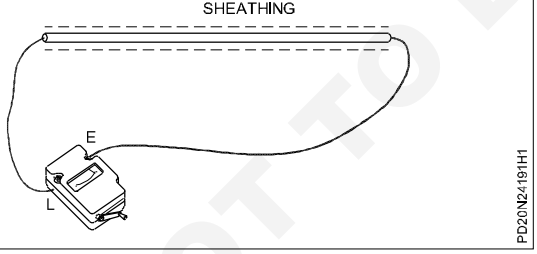
TASK 1: **Locate open circuit faults in underground cable**

This test is made to check whether the cable insulation is in open condition and to identify the exact location of the open circuit.

1 Switch 'OFF' the mains. Remove the fuse and the neutral links in the main switch and keep them in safe custody.

2 Select 500 V Megger and connect one terminal of the Megger, say L, to the one end of cable as shown in Fig 1.

Fig 1



3 Connect the other terminal of the Megger say 'E' to the other end of the cable.

4 Rotate the megger at 160 r.p.m.

5 Observe the megger reading. If the megger shows infinity, there is open circuit in the cable.

Open circuit may be due to open in the cable.

If the megger shows '0' reading, it indicates no open in the cable.

6 Connect the 'E' terminal near the middle of the cable and repeat the above procedure for open circuit.

If it shows '0' reading, there is no open in between 'L' and the middle of the cable.

7 Repeat the above procedure, connecting the 'E' terminal to beyond the middle point of the cable at varied distances.

When the megger shows infinity in a parhcilar place, that is the point of open.

8 Locate the faulty portion and make fresh straight joint to the UG cable.

— — — — —

TASK 2: **Locate the short circuit fault in U.G cable**

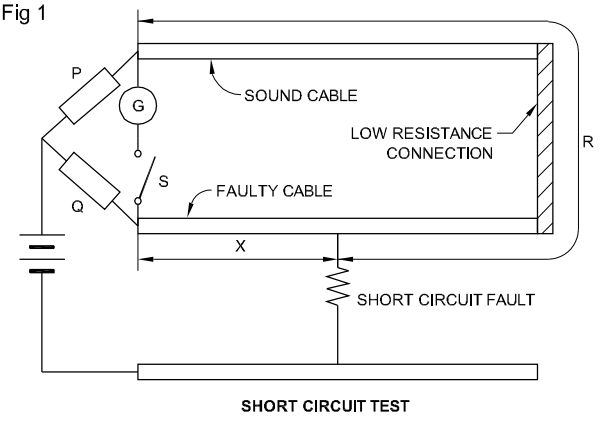
This test is made to locate the short circuit in the cable by Murray loop test.

1 Switch 'OFF' the main switch. Remove the fuse of the main switch and keep it in safe custody.

2 Select a Wheatstone bridge and connect one end of the cable to the meeting point of P and Galvanometer and another cable end to the meeting point of Q and Galvanometer as shown in Fig 1.

3 Measure the length of each cable.

Fig 1



SHORT CIRCUIT TEST

4 Connect the other two ends of both the cables by means of low resistance wire.

5 Take the battery terminal (negative) wire and place it at any point of the cable and observe the deflection in the Galvanometer.

The area of the cable where the Galvanometer shows '0' reading is the exact location of the short circuit. It can be calculated with the formula given below.

$$(i.e)\frac{x}{p}=\frac{Q}{P} \text{ or } \frac{X}{R+X}=\frac{Q}{P+Q}$$

where X is the length of the fault from the test end.

L is length of each cable.

6 Locate the fault while measuring the length of the cable and clear the short circuit in the UG cable.

— — — — —

TASK 3: **Locate the ground fault in U.G cable**

This test is also done to locate ground fault in the cable by Murray Loop test.

1 Connect the cables as shown in the Fig 1 and repeat the steps explained in the short circuit test (task 2).

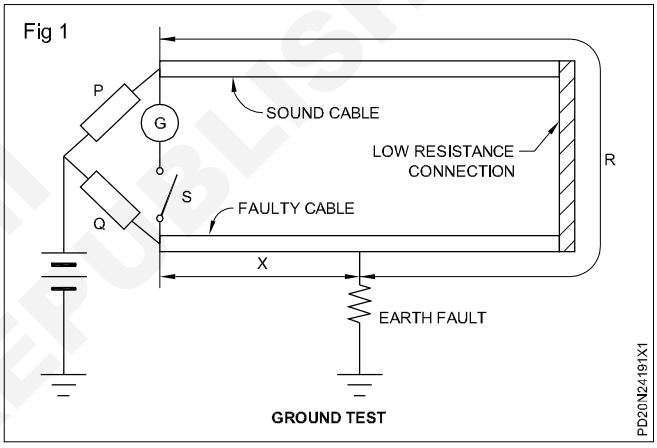
The area of the cable where the Galvanometer shows '0' reading is the exact location of the ground fault.

2 Calculate and locate the place of the ground fault as given below.

$$X = \frac{Q}{P+Q} \times 2L$$

Where 'X' is the length of the fault from the test end.

Fig 1



GROUND TEST

3 Locate the place where the ground fault is by measuring the length from the test end and repair the fault.

— — — — —

Identify current transformer it's specifications and carryout visual inspection

Objectives: At the end of this exercise you shall be able to
- **identify current transformer**
- **carry out visual inspection.**

Requirements

Tools/Instruments

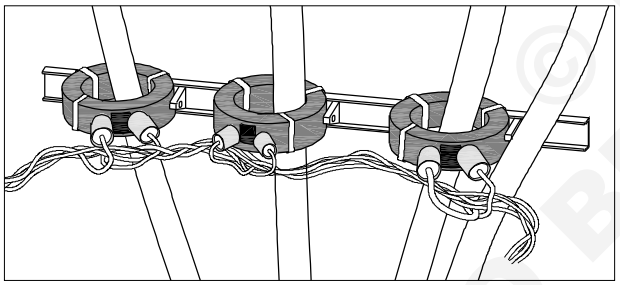
• A4 paper	- 4Nos.	• Eraser	-1No.
• Pencil/HB	- 1No.	• Scale	-1No.

The Instructor may take the trainees to the nearest power motor control unit or substation and help tranees to identify current transformer and observe its specifications from name plato.

PROCEDURE

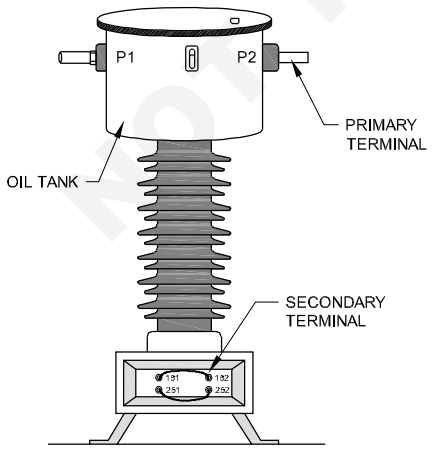
Current Transformer is designed to maintain an accurate ratio between currents in its primary and secondary circuit over a defined range. Current Transformer performs circuit control and current measure ment for power measurement. Current Transformer is a modified step up transformer.

Fig 1



PD20N25192H1

Fig 2



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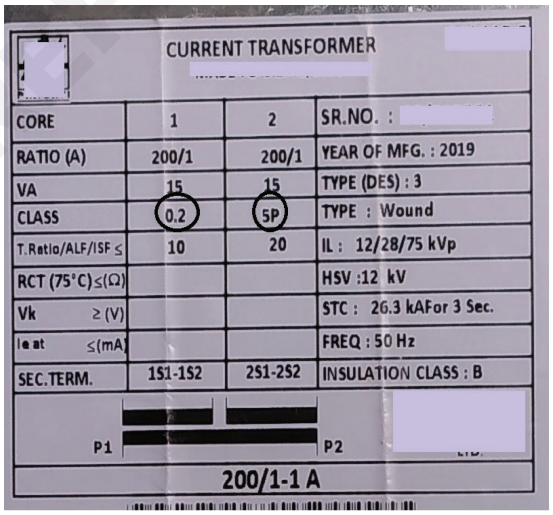
Specifications of Current transformer are rated current, accuracy class, burden, primary and secondary winding details, insulation levels, and any other relevant information. The specifications can vary based on the application and requirements.

Fig 3



Manufactures name & SL No.	
Ratio	
VA	
Frequency	
Class	
Make	

Carryout ratio test on current transformer

Objectives: At the end of this exercise you shall be able to

- **carryout ratio test by applying suitable voltage to secondary winding of CT and measuring the voltage from the primary side**
- **carryout ratio test by applying current to primary windind and measuring current in secondary**

Requirements

Tools/Instruments

- Calibrated test set - 1No.
- CT test leads - 1No.
- Appropriate safety gears - 1No.
- Ammeter - 1No.

Ensure that the CT is disconnected from the circuit to avoid any risk of electric shock during the test.

PROCEDURE

- Connect the primary winding of the CT to the test set's output terminals.
- Connect the secondary winding of the CT to the test set's input terminals.
- Apply a known primary current to the CT by setting the test set to a specific current value.
- Measure the secondary current produced by the CT and recorded the value.(Fig 1& 2)

Sl. No	Primary Current Ip	Secondary Current Is
1		
2		

Sl. No	Primary V	Secondary V
1		
2		

- Calculate the ratio of primary current to secondary current. The formula is:
- Ratio = Primary Current / Secondary Current (or) Ratio = Secondary Voltage/ Primary Voltage
- Compare the calculated ratio with the CT's nominal ratio (specified by the manufacturer)

Safety Precautions:

- Always follow proper safety procedures when working with electrical equipments Ensure that circuits are de-energized and isolated before making any connections.
- Use appropriate personal protective equipment (PPE) to minimize the risk of accident

Fig 1

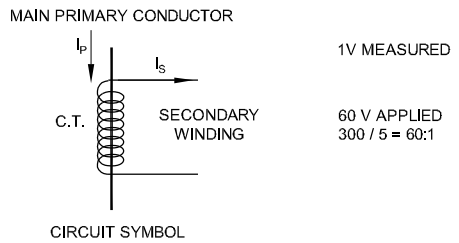
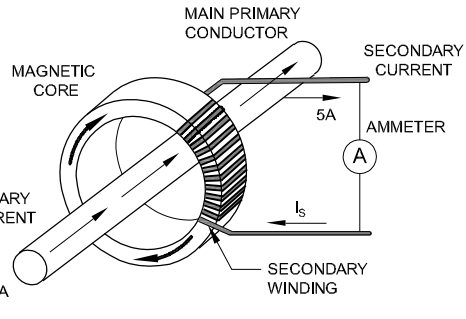


Fig 2



Carry out polarity test on current transformer

Objectives: At the end of this exercise you shall be able to
- **do polarity test on CT.**

Requirements

Tools/Instruments

- Personal protective equipments - 1set.
- Electrician's Tools - 1set.
- Analog Multi meter - 1No.
- 9v Battery - 1No.
- CT meter - 1No.

PROCEDURE

Disconnect all power prior to testing and connect the analog multimeter to the secondary terminal of the CT to be tested. The positive terminal of the meter is connected to terminal X1 of the CT while the negative terminal is connected to X2.

Run a piece of wire through the high side of the CT window and shortly make contact with the positive end of the 9-volt battery to the H1 side (sometimes marked with a dot) and the negative end to the H2 side. (It is important to avoid continuous contact, which will short circuit the battery).(Fig 1&2)

If polarity is correct, the momentary contact causes a small deflection in the analog meter in the positive direction. If the deflection is negative, the polarity of the current transformer is reversed. The terminals X1 and X2 need to be reversed and the test can be carried out.

Note: Polarity is not important when connecting to ammeters and voltmeters. Polarity is important only when connecting to wattmeters, watt-hour meters, varmeters, and induction-type relays. To maintain polarity, the H1 side of the CT must be toward the source of power; then the X1 secondary terminal is the polarity connection.

Fig 1

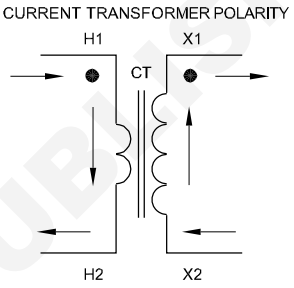
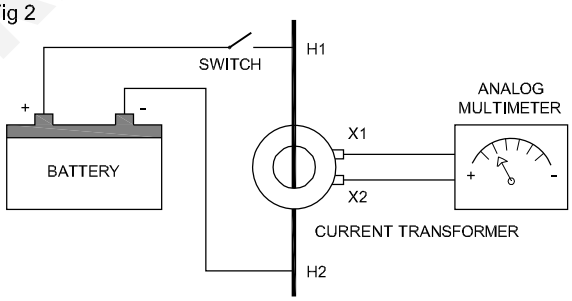


Fig 2



Check insulation resistance of CT

Objectives: At the end of this exercise you shall be able to
- **check insulation resistance of CT.**

Requirements

Tools/Instrument

- Insulation Resistance Tester (Megohmmeter) With connecting codes - 1No.
- Safety equipment (gloves, goggles, appropriate clothing) - 1set
- Wiring diagram of the CT and associated connections - 1copy
- Access to the CT terminals
- Precautions for safety and proper grounding

PROCEDURE

Ensure the CT is disconnected from the electrical system to prevent any live currents during testing.

Put on appropriate safety gear.

Verify that the CT terminals are clean and dry to ensure accurate readings.

Check the wiring diagram to identify the CT terminals that need to be tested.

Set the insulation resistance tester to the appropriate test voltage, usually 500V or 1000V, depending on the system voltage and CT type

Connect the positive and negative leads of the tester to the CT terminals being tested. The positive lead goes to the terminal being tested, and the negative lead goes to the CT core or the ground.

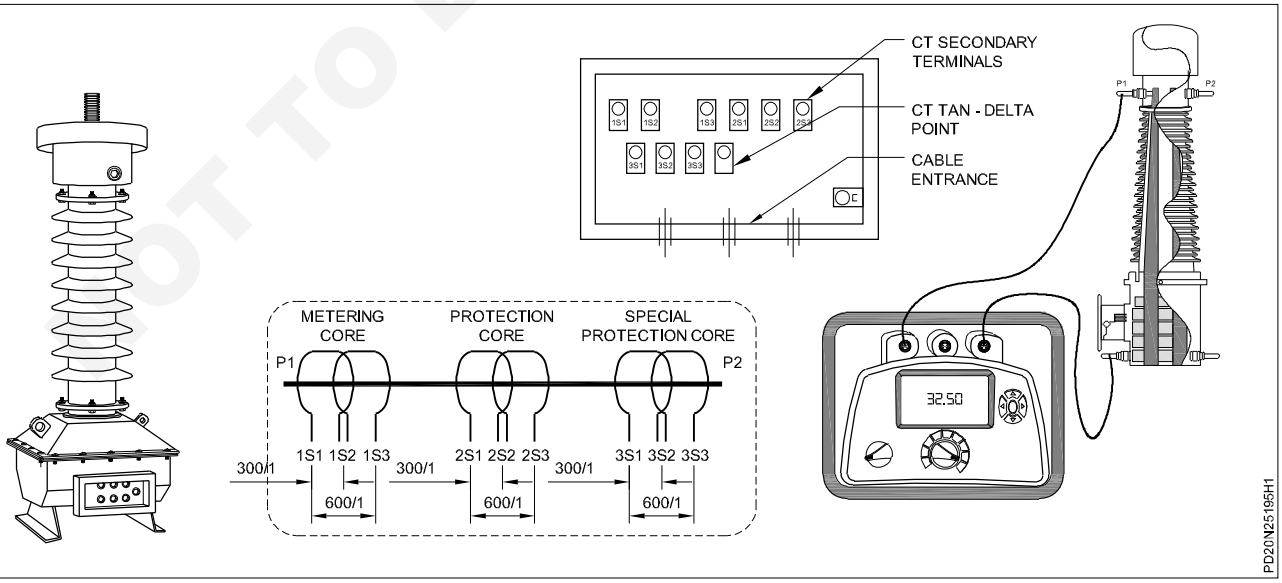
Initiate the insulation resistance test and allow the tester to apply the test voltage for a specific duration (usually 1 minute).

The tester will display the insulation resistance value in ohms or megohms. Record this and get it verified by your instructor

Sl. No.	Insulation resistance value
1	
2	

Once the test is completed, disconnect the leads and restore the CT to its normal operating condition.(Fig 1)

Fig 1



Carry out winding resistance test on CT

Objectives: At the end of this exercise you shall be able to
- **carryout winding resistance test on CT**

Requirements

Tools/Instruments

- Multimeter - 1No.
- Test Current Source - 1No.
- Test Leads - as reqd.
- Proper personal protective equipment (PPE) - 1Set
- CT Specifications - 1Copy
- Wiring Diagram - 1Copy

Ensure the CT is isolated from the system to prevent unwanted current flow during testing.

PROCEDURE

Ensure that the CT is de-energized and isolated from the system.

Follow all safety protocols.

Connect the test leads according to the wiring diagram. Connect the multimeter to measure resistance and the test current source to inject current.

Inject a known test current (typically around 10-20% of the rated current) into the primary winding using the test current source.

Measure and record the voltage drop across the CT winding while the test current is flowing. Use Ohm's law $R = \frac{V}{I}$ to calculate the resistance.

Record all test data, including the CT's serial number, test current, voltage drop, calculated resistance, and the comparison with specifications.

Repeat the test for each winding (primary and secondary) if applicable.

Disconnect the test current source, remove the test leads, and ensure the CT is safely reconnected to the system. (Fig 1)

Primary winding

Sl. No	Voltage	Corrent	Resistance
1			
2			
3			

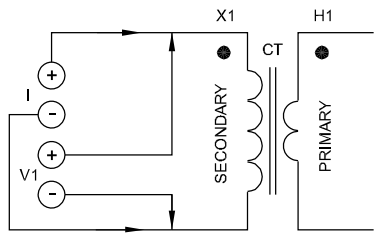
Secondary winding

Sl. No	Voltage	Corrent	Resistance
1			
2			
3			

Calculates winding resistance by ohms law

$$R = \frac{V}{I}$$

Fig 1



CURRENT TRANSFORMER WINDING RESISTANCE TEST CONNECTIONS.

Carryout Excitation (Saturation)test on CT

Objectives: At the end of this exercise you shall be able to
- **carryout excitation test on CT**

Requirements

Tools/Instruments

• Multimeter	- 1No.	• PPE kit	- 1No.
• CT (any range)	- 1No.	• Electrician's kit	- 1No.

PROCEDURE

Disconnect the CT from the circuit to ensure safety during testing.

Confirm the CT ratio, nominal burden, and saturation characteristics from the CT datasheet.

Connect the secondary terminals of the CT to a burden resistor that simulates the actual load.

Connect the primary terminals of the CT to the variable AC voltage source

Ensure all connections are secure and insulated.

Apply a gradually increasing AC voltage on the primary side while monitoring the secondary side output.

Record the secondary current and voltage corresponding to different primary voltages.

Observe the CT's response and ensure it follows the expected linear behavior up to a certain point.

Continue increasing the primary voltage until the CT's output current reaches a point of saturation.

Note the voltage level at which the CT saturates, and the corresponding secondary current.

Saturation occurs when the core becomes magnetically saturated, leading to non-linear behavior.

Plot the secondary current vs. primary voltage curve.

Determine the knee point, where the CT starts to saturate.

Compare the results to the manufacturer's specifications and industry standards.

Assess whether the CT's behavior aligns with expected characteristics.

Verify that the saturation point is within acceptable limits and doesn't compromise accuracy under normal operating conditions.(Fig 1&2)

Sl. No.	Primary Voltage	Secendary Curent
1		
2		
3		
4		
5		
6		
7		
8		

Fig 1

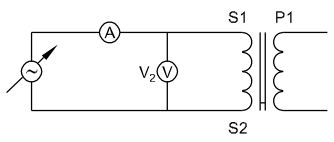


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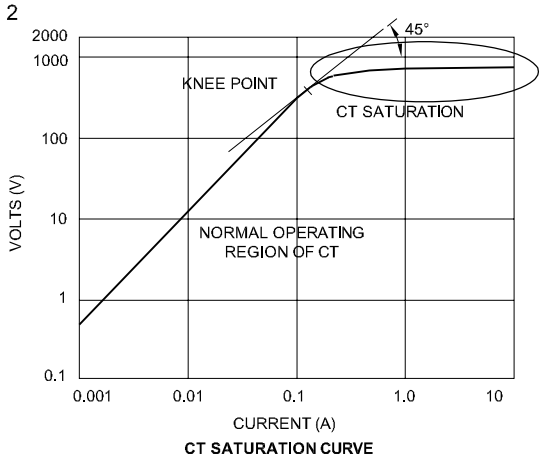
Fig 2



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Carry out burden test on current transformer

Objectives: At the end of this exercise you shall be able to
- **carryout Burden test on CT**

Requirements

Tools/Instruments

• calibrated current source	- 1No.	• CT (any range)	- 1No.
• Burden Resister	- 5Nos.	• PPE kit	- 1Set.
• Multimeter	- 1No.	• Eletrician's kit	- 1Set.

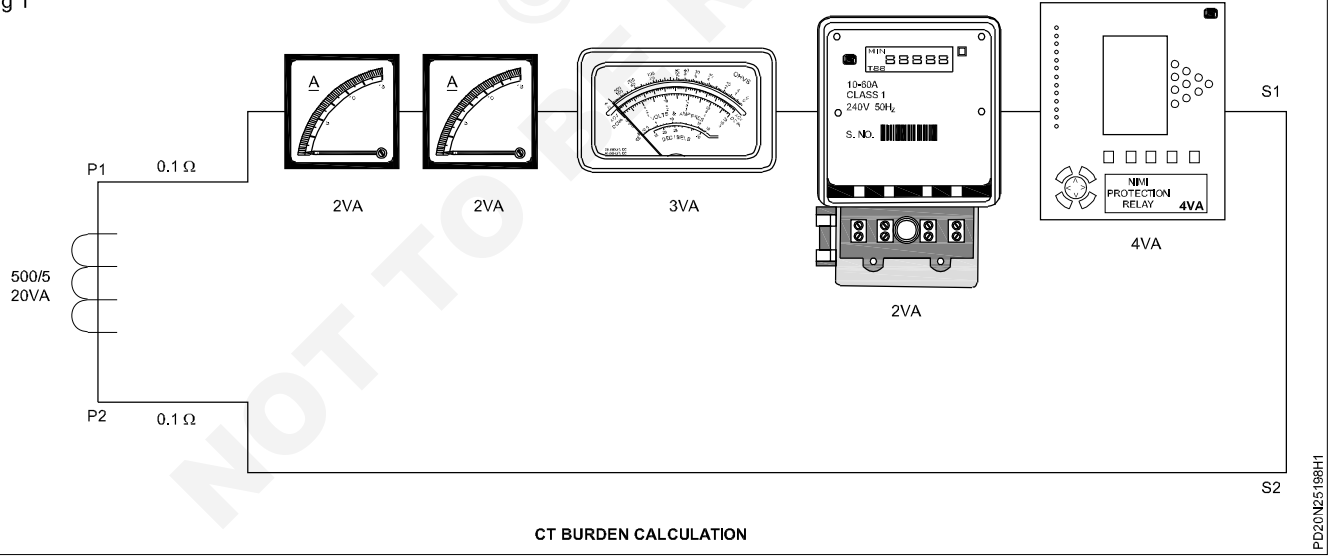
PROCEDURE

- Connect the primary side of the current transformer to a calibrated current source.
- Connect the secondary side of the current transformer to a burden resistor, and then connect the other end of the burden resistor to the measurement equipment (such as a multimeter or secondary injection test set).
- Ensure proper grounding of the setup Begin with a no-load condition where the secondary side is open. Record the voltage output.
- Gradually increase the load by reducing the burden resistance, simulating different levels of current flow
- For each load condition, measure the current input to the primary side and the voltage output on the secondary side.
- Calculate the burden voltage by using Ohm's law: Burden Voltage = Current x Burden Resistance.

Current Resistance Voltage.

Verify readings with your instructor. (Fig 1)

Fig 1



CT BURDEN CALCULATION

Total instrument Burden = 2+2+3+2+4

Total pilot load resistance = 2x0.1=0.2 Ω s.

Voltage drop in leads = 5x0.2 = 1v (V=IxR)

Carryout knee point voltage test of protection core

Objectives: At the end of this exercise you shall be able to
- **carryout knee point voltage test of protection core.**

Requirements

Tools/Instruments

• Variable AC source	- 1Set.	• wiring cable	- as reqd.
• Current injection source	- 1Set.	• PPE kit	- 1Set.
• Multimeter	- 1No.	• Electrician's kit	- 1Set.

PROCEDURE

- Connect the voltage source and the current source to the protection core as per the manufacturer's guidelines.
- A reliable multi-meter to measure the voltage and current during the test. Record the voltage and current readings accurately.Ensure the protection core is properly installed and connected. Make sure the test setup is safe and follows standard safety protocols.
- Set the variable AC voltage source to its lowest value. Keep the current source of Apply the lowest voltage to the protection core. Record the voltage and corresponding excitation current.
- Increase the applied voltage gradually to 20, 30, 40, 50, 60, 70, 80, 90% of the rated Vkneepoint of the CT and note down the secondary current. Now increase the voltage to 100% of rated Vkneepoint and note down the current At some point, the core will enter the saturation region where the increase in voltage results in a much smaller increase in current.
- The knee point is the point where the core's magnetization curve deviates from linearity. It's the point where a significant increase in current occurs even with a slight increase in voltage
- Analyze the recorded data to identify the knee point where the magnetization curve changes. This is a critical point for core protection coordination.
- •• Create a plot of the magnetization curve using the recorded data points. The knee point is where the curve's slope changes. Compare the measured knee point with the manufacturer's specified knee point
- Document the test results, including the knee point voltage and current values, the plot of the magnetization curve, and observations.

Remember to follow safety procedures and manufacturer guidelines throughout the test Verify the readings and graph by your Instructor

Sl. No.	Voltage	Current
1		
2		
3		
4		
5		
6		
7		
8		

Fig 1

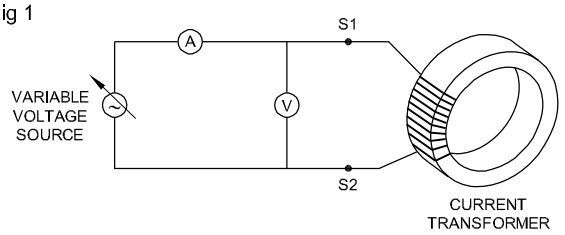
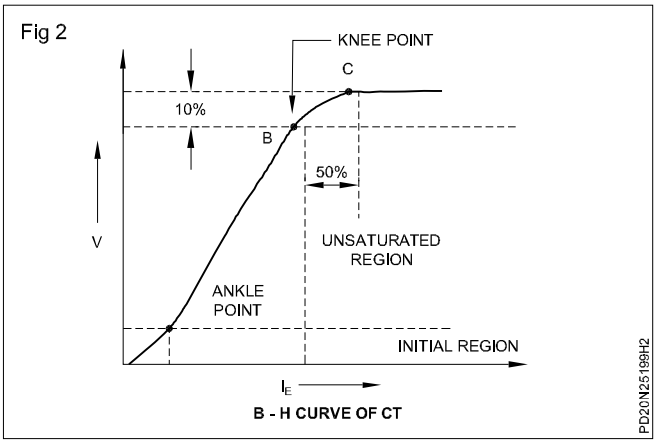


Fig 2



Carry out ratio change of CT by Changing taps in primary and Secondary side

Objectives: At the end of this exercise you shall be able to
- **carry out ratio change of CT by changing by changing taps in primary side**
- **carry out ratio change of CT by changing taps in secondary side.**

Requirements

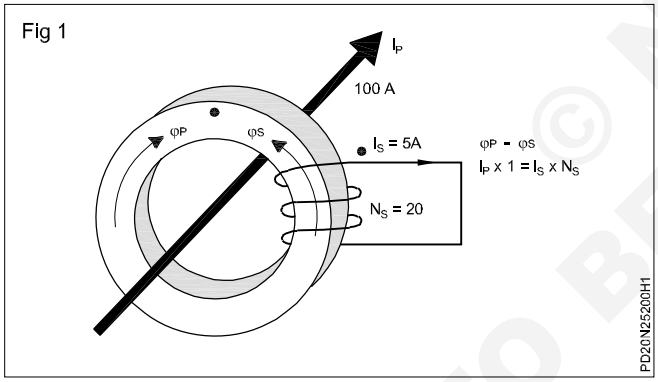
Tools/Instruments

- Current transformer 100:5 - 1No.
- Multi meter - 1No.
- AC supply source - 1Set.
- PPE kit - 1Set.
- Electrician's kit - 1Set.

PROCEDURE

A window-type current transformer is also referred to as a core-balance or flux-balance transformer. These names reveal the operating principle of the transformer-neglecting magnetizing current, current will flow in the secondary such that the magnetomotive force (mmf) from the secondary (in ampere turns) will be equal and opposite to the mmf resulting from primary current. (Fig 1)

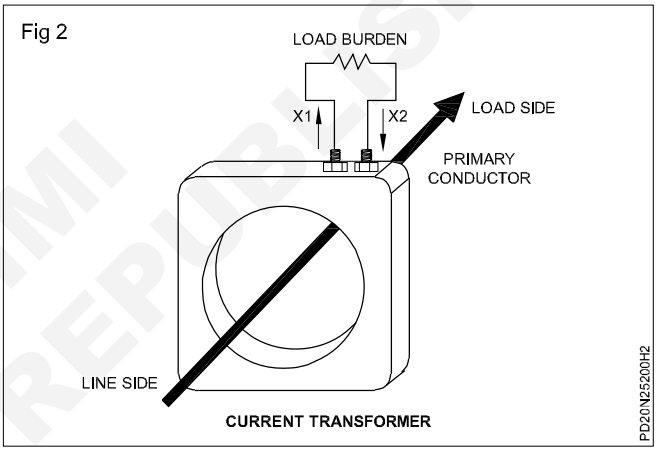
Fig 1



The ratio of a CT's primary rating to its secondary rating is equal to the number of secondary turns. For example, a CT with a 5-A secondary and 20 turns will have a nameplate ratio of 100:5. This ratio is based on the primary conductor passing once through the transformer window. If multiple primary turns are used, the ratio will be reduced by the number of times the primary conductor passes through the transformer window. For example, a 100:5 transformer will look like a 50:5 transformer if the primary conductor passes twice through the transformer window.

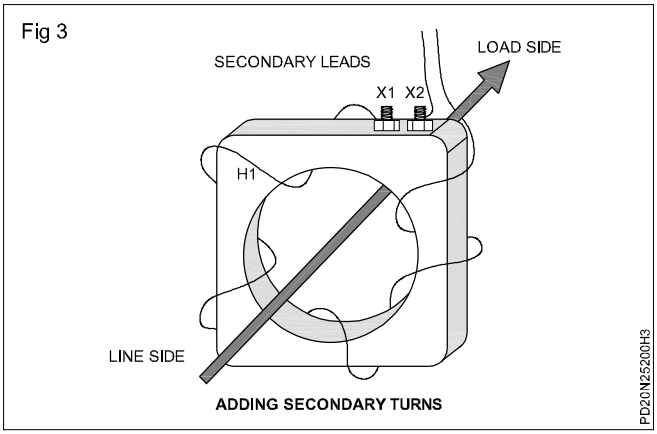
Adding or subtracting secondary turns can also change the ratio of a current transformer. A current transformer will have the line side of its primary marked H1 and the end of its secondary winding with the same polarity marked X1 (see Fig 2). or it will have H1 and X1 indicated with dots.

Fig 2



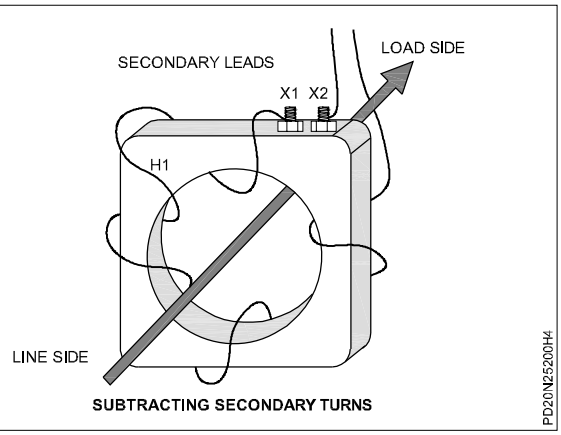
To increase the CT ratio, the number of secondary turns must be increased. To add turns to the secondary winding pass the X1 secondary lead through the transformer window from 112 to H1. as shown in Fig 3

Fig 3



To decrease the CT ratio, the number of secondary turns must be decreased To subtract external turns from the of CT secondary winding, pass the X1 secondary lead through the transformer window from H1 to H2, as shown in Fig 4

Fig 4



SUBTRACTING SECONDARY TURNS

Example 1: To increase a 25-5 A CT to a ratio of 100-5 A, 15 turns must be added to the CT secondary-a 25-5 A CT has a turns ratio of 5:1, and a 100-5 A CT has a turns ratio of 20:1. Pass the X1 secondary lead through the transformer window 15 times from H2 to H1.

CT Ratio	Turns Added to 25-5 A CT Secondary	Turns Ratio
25 - 5 A	0 turns	5:1
50 - 5 A	5 turns	10:1
75 - 5 A	10 turns	15:1
100 - 5 A	15 turns	20:1

Example 2: To decrease a 500-5 A CT to a ratio of 425-5 A, 15 turns must be subtracted from the CT secondary-a 500-5 A CT has a turns ratio of 100:1, and a 425-5 A CT has a turns ratio of 85:1. Pass the X1 secondary lead through the transformer window 15 times from H1 to H2.

CT Ratio	Turns Added to 25-5 A CT Secondary	Turns Ratio
500 - 5 A	0 turns	100:1
475 - 5 A	5 turns	95:1
450 - 5 A	10 turns	90:1
425 - 5 A	15 turns	85:1

NOTE 1: There will be an extra burden on the CT from the additional lead length required to wrap the CT

NOTE 2: Changing the CT turns ratio is not a desirable method for sizing CT's. It is better to properly size the CT ratio to the specific application. When the CT ratio is changed using this method, the CT manufacturer's data will no longer apply to the CT

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Perform installation and commissioning of current transformer

Objectives: At the end of this exercise you shall be able to
- **carryout installation of current transformer.**

Instructor may take trainees to substation with permission from Engineering charge to understand installation and commissioning of current transformer.

Requirements

Tools/Instruments

- Insulation tester - 1No.
- Polarity tester - 1No.
- Digital ohm mete - 1No.
- multimeter - 1No.
- Variac, step up transformer - 1No.
- Primary current injection set - 1Set.
- Electrician's kit - 1Set.
- PPE kit - 1Set.

PROCEDURE

1 Verify name plate ratings are in accordance with the approved drawings and specifications

2 Inspect for physical damage defects and mechanical condition

3 Verify correct connection of Transformers with system requirements

4 Verify that educate clearances exist between primary and secondary circuit wiring

5 Verify titness of accessible bolted electrical connections

6 Verify that all required grounding and sorting connection provided

7 Verify all sorting blocks are in correct position either grounding or open as required

8 Verify single point grounding of each for done properly grounding point shall be near to the current transformer location however grounding shall be at relay point in case of several CT secondary connected together like differential protection

Following tests are to be conducted before commissioning a current transformer

1 Insulation resistance test Ex.No 2.5.195

2 Polarity test Ex.No 2.5.194

3 Burden test Ex.No 2.5.198

4 Magnetisation curve test Ex.No 2.5.197

5 Tum ratio test Ex.No 2.5.193

Identify potential transformers, it's specifications and visual inspection

Objectives: At the end of this exercise you shall be able to
- **identify potential transformer**

Potential Transformer-Name Plate Specifications (Fig 1&2)

1 Rated Primary Voltage:

It is the rated continuous thermal limit voltage.

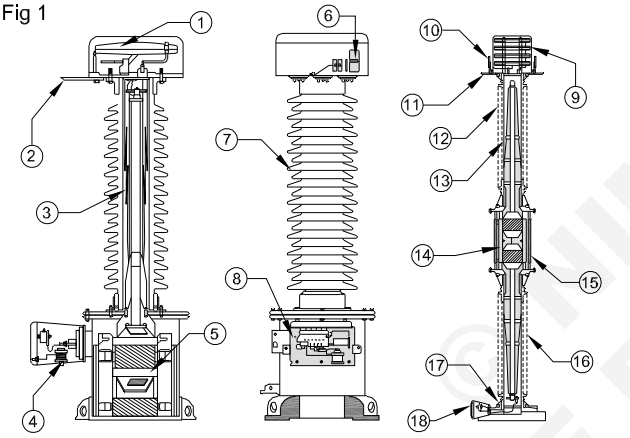
2 Rated Secondary Voltage:

The rated secondary voltage usually 110/√3

3 Rated Burden:

PT is rated by maximum burden (VA) at which it remains within specified limits of error.

Fig 1



1. EXPANSION BELLOW
2. PRIMARY TERMINAL
3. BUSHING
4. SECONDARY TERMINAL BOX
5. CORE / COIL ASSEMBLY
6. OIL-LEVEL INDICATOR
7. PORCELAIN / COMPOSITE INSULATOR
8. SECONDARY TERMINAL BOX
9. EXPANSION BELLOW
10. LIFTING EYE
11. PRIMARY TERMINAL
12. POST TYPE PORCELAIN INSULATOR
13. BUSHING
14. TWO COIL & CORE ASSEMBLY
15. TRANSFORMER TANK
16. POST TYPE PORCELAIN / COMPOSITE INSULATOR
17. OIL TO AIR SEAL BOCK
18. SECONDARY TERMINAL BOX

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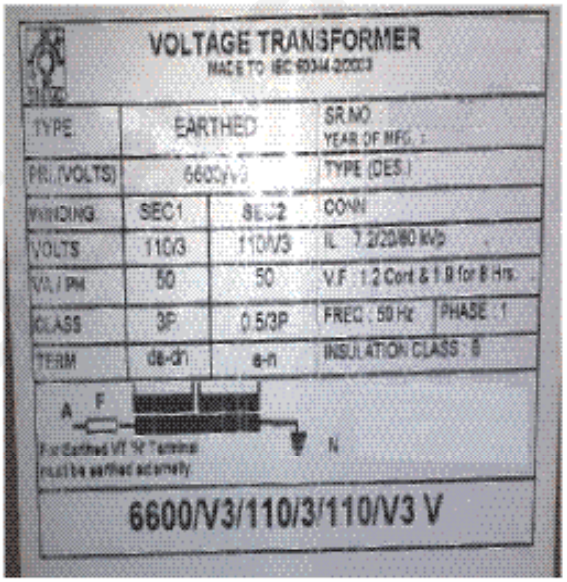
4 Insulation Level:

Combination of power frequency and impulse voltages at which PT can withstand.

5 Rated Voltage Factor:

The multiplying factor to be applied to the rated primary voltage to determine the maximum voltage at which a transformer must comply with the relevant thermal requirements for a specified time and with relevant accuracy requirements.

Fig 2



Winding to winding and each winding to ground

Objectives: At the end of this exercise you shall be able to
- **insulation resistance test of potential transformer.**

Requirements

Tools/Instruments

- Potential Transformer - 1No.
- Insulation Resistance Tester500V - 1No.
- PPE - 1Set.
- Safety glasses - 1Set.

PROCEDURE

1 Clean the PT and ensure it's dry.

2 Record the PTs nameplate data, including rated voltage and insulation class.

3 Set the insulation resistance tester to 500 V DC range.

4 Ensure the tester is functioning properly and calibrated.

a) Winding to Winding Test.

- Connect one lead of the megohmmeter to one winding of the PT.
- Connect the other lead of the megohmmeter to another winding of the PT.
- Measure the insulation resistance and record the value.

b) Each Winding to Ground Test.

- Disconnect the megohmmeter leads from the winding-to-winding test.
- Connect one lead of the megohmmeter to a winding of the PT.
- Connect the other lead of the megohmmeter to the ground terminal or the grounded part of the PT.
- Measure the insulation resistance and record the value.
- Compare the measured insulation resistance values to the acceptable range for the PT's insulation class If the readings are within the specified range, the insulation is considered good.
- Document all test results including the date equipment used, measured values, and any observed anomalies.

Table 1 Insulation Resistance on winding to winding Test.

S/No	Winding to winding Test
1	
2	

- After completing the insulation resistance test. reconnect the PT to the electrical system.
- Ensure that all safety measures are taken before the energizing.

Fig 1

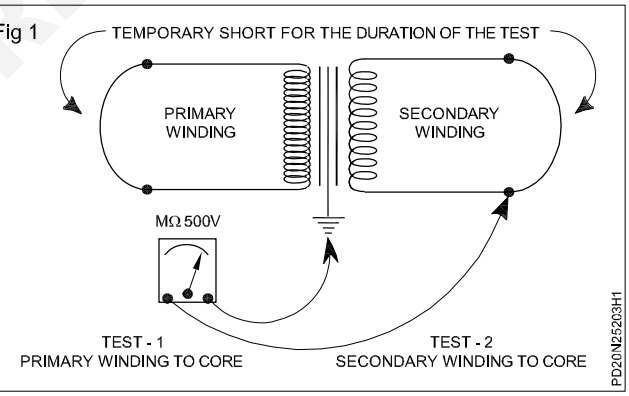
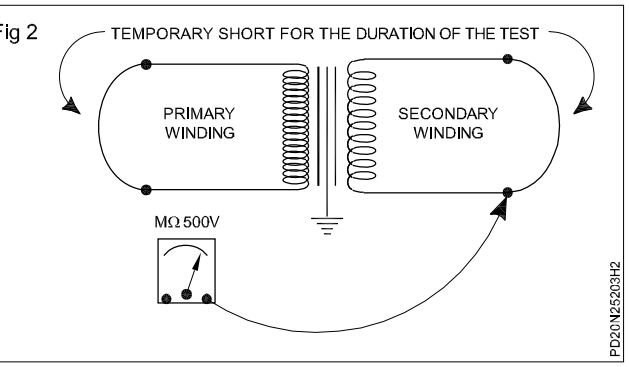


Fig 2



Sl.No.	Winding	Insulation resistance
1	Primary winding to ground (1)	
2	Primary winding to ground (2)	
3	Secondry winding to ground (1)	
4	Secondary winding to ground (2)	

— — — — —

Carryout polarity test on PT

Objectives: At the end of this exercise you shall be able to
- **carryout polarity test on PT.**

Requirements

Tools/Instruments

- Voltmeter - 1No.
- Electrician's kit - 1No.
- Potential transformer - 1No.
- Insulation resistance Tester - 1No.
- PPE kit - 1Set.
- Electrician's kit - 1Set.

PROCEDURE

1 Connect the circuit as shown in the above circuit diagram figure and set the autotransformer to zero position.

2 Switch on the single-phase supply

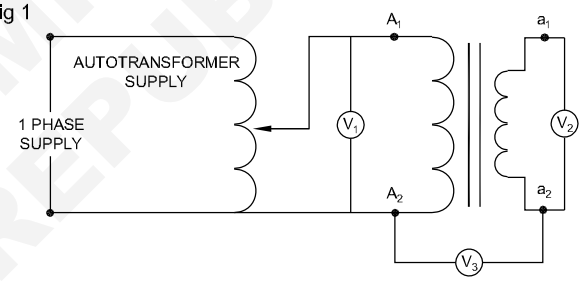
3 Record the values of the voltages as shown by the voltmeter V1, V2 and V3.

4 If the reading of the V3 shows the addition of the value of V1 and V2 that is V2 = V1+V2 the transformer is said to be connected in additive polarity.

5 If the reading of the V3 is the subtraction of the readings of V1 and V2, then the transformer is said to be connected in subtractive or negative polarity.

Voltmeter reading (1)	Voltmeter reading (2)	Voltmeter reading	$V_1 + V_2$

Fig 1



Perform turns ratio test on PT

Objectives: At the end of this exercise you shall be able to
- **conducting turns ratio on PT.**

Requirements

Tools/Instruments

- Variable power supply V 0-500 AC - 1 No.
- Voltmeter 480V - 1 No.
- Voltmeter 120V - 1 No.
- A4 sheet - 2 Nos.
- Pen/Pencil - 1 No.

PROCEDURE

a Connect the variac across the primary winding.

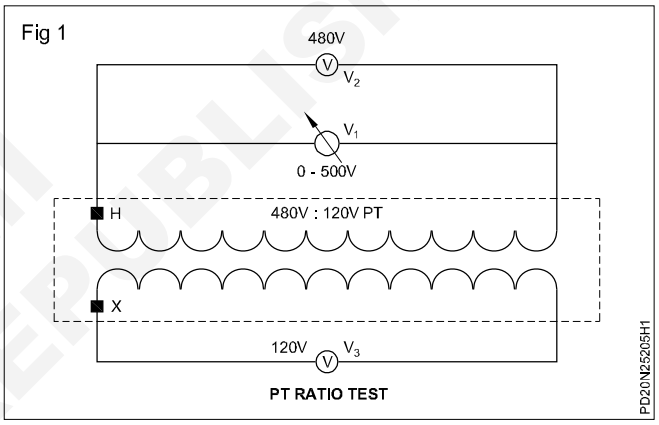
b Increase the voltage to the test voltage. (Typically an easy multiple of the PT ratio e.g. 35:1V PT ratio =35V) Calculate the expected secondary voltage.] (Test voltage /PTRatio)

c Measure the secondary voltage and compare to the expected result.

d After the ratio tests have been completed, ensure that the connection is left as specified.(Fig 1)

Note: Never energize the secondary winding and measure the primary winding as dangerous voltages could be created.

Fig 1



Voltmeter reading V1	Voltmeter reading V2	Voltmeter reading V3

Perform Installation and commissioning of potential transformer

Objectives: At the end of this exercise you shall be able to
- **installation and commissioning of PT.**

Instructor may take trainees to substation with permission from Engineering incharge to understand installation and commissioning of potential transformer

Requirements

Tools/Instruments

- Potential transformer
- Multimeter
- Earth kit (complete)
- Electrician's kit
- Earth kit complete for grounding - 3set.
- spirit level - 1No.
- A4 paper - 2Nos.
- Pen/pencil - 1No.

PROCEDURE

1 Ensure you're following all safety guidelines and using appropriate personal protective equipment.

2 Select a suitable location for the potential transformer.

3 Fix the potential transformer securely to a stable surface.

4 A Primary Side: Connect the primary side of the potential transformer to the high voltage circuit. Connect the secondary side to the measuring or protection equipment. This connection will typically involve the use of appropriate cables and connectors.

5 Ground the potential transformer's secondary circuit according to local regulations and safety standards.

6 Before commissioning, perform insulation resistance tests to verify the integrity of the insulation between primary and secondary windings, as well as between windings and ground.

7 A Conduct a ratio test to verify that the potential transformer's turns ratio matches the manufacturer's specifications.

a Verify the polarity of the potential transformer to ensure that the phase relationship between primary and secondary sides is correct.

b Test the burden of the potential transformer by connecting it to the intended load and measuring the output voltage under load conditions

c Test the secondary circuit for continuity and proper connection.

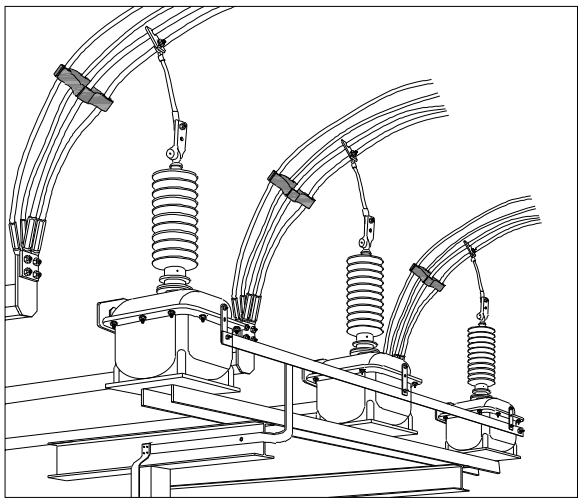
8 Once all tests and verifications are successful, energize the system and monitor the performance of the potential transformer under normal operating conditions.

9 Create a comprehensive record of all the tests conducted, results obtained, and any adjustments or calibrations made.

10 Properly label the potential transformer with its details, including manufacturer, serial number, ratio, and installation date.

Remember that these steps are general guidelines and may vary based on the specific manufacturer's instructions.(Fig 1)

Fig 1



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Identify isolation transformer and its specifications

Objectives: At the end of this exercise you shall be able to
- **identify isolation transformer**
- **identify specifications.**

Requirements

Tools/Instruments

• Isolation transformer	- 1 No	• pen/pencil	- 1No.
• A4 paper 2	- 2 No	• Megha ohmmeter	- 1No.
		• hipot tester	- 1No.

PROCEDURE

1 Look for 6 labels or markings on the transformer that indicate it's an isolation transformer. It might be explicitly mentioned on the casing or in the documentation.

2 Measure the resistance between the primary and secondary windings. In an isolation transformer, there should be no continuity or very high resistance between them.

3 An isolation transformer's primary and secondary voltage ratings are usually the same. If you find a transformer with the same input and output voltages, it's likely an isolation transformer.

4 Use a high-potential (hipot) tester to check for isolation between the windings. This test ensures that the transformer can withstand a high voltage between the primary and secondary coils without conducting.

5 Use a multimeter in resistance or continuity mode to ensure there is no direct connection between the primary and secondary windings.

6 If you have access to the manufacturer's documentation or specifications, it should clearly mention whether the transformer is an isolation type.

7 Remember that ensuring proper safety precautions while handling electrical equipment is crucial during these.

Fig 1

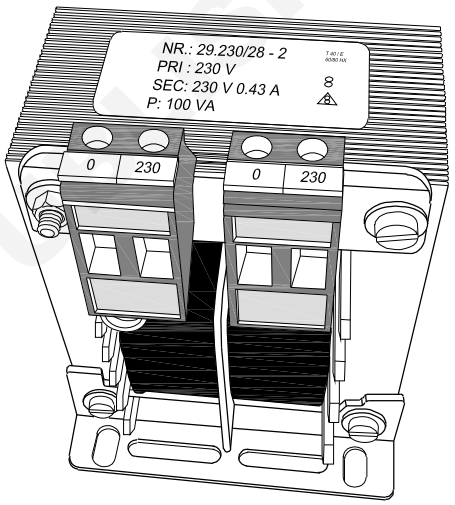
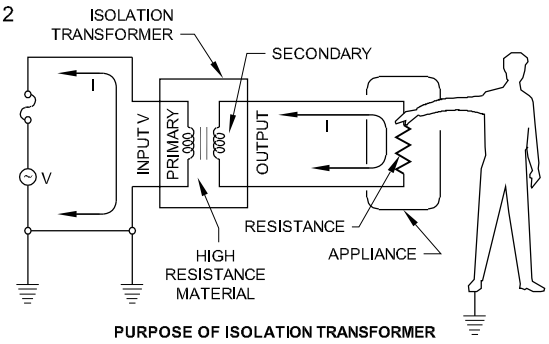


Fig 2



Carryout repair/ replacement and maintenance of CT and PT

Objectives: At the end of this exercise you shall be able to
- **carryout repair of CT/PT**
- **carryout replacement of CT/PT**
- **carryout maintenance of CT/PT**

Requirements

Tools/Instruments

• Megha ohm meter	- 1No.	• Electrician's kit	- 1Set.
• Cotton waste	- as reqd.	• PPE kit	- 1Set.
• Cleaning solution	- as reqd.	• Transformer oil (If required)	- as reqd.

PROCEDURE

1 Examine the CT/PT for physical damage, signs of corrosion, loose connections, and any unusual conditions.

2 Ensure the power supply is disconnected to avoid any electrical hazards during the maintenance process.

3 Perform insulation resistance tests to check for any insulation breakdown. Use a megohmmeter to measure the resistance between windings and to ground.

4 Clean the external surfaces of the CT/PT to remove dirt, dust, and debris. Use a non-corrosive cleaning agent and a soft cloth.

5 If the CT/PT is oil-filled, check the oil level, color, and dielectric strength. Replace the oli necessary Inspect all terminals, connectors, and cable connections for tightness. Re-tighten if needed.

6 Testing Accuracy: Conduct ratio and polarity tests to ensure the CT/PT's accuracy is within acceptable limits. This may involve using a test set and comparing the output to the known input.

7 Check the alignment of internal components, ensuring that they are properly secured and not subject to vibrations or movement.

8 If applicable, take oil samples for analysis to assess the condition of the insulation and identify any potential issues.

9 Perform dielectric tests to verify the insulation integrity between windings and to ground. This helps ensure the safety and reliability of the CT/PT

10 If required, calibrate the CT/PT to ensure its accuracy matches the specified standards.

11 After the maintenance is completed, seal the CT/PT to prevent tampering and protect it from environmental factors.

12 Maintain a detailed record of all maintenance activities performed, including test results, repairs, and replacement.

13 Once all checks and repairs are completed, reassemble the CT/PT and reconnect it to the power supply, following proper safety procedures.

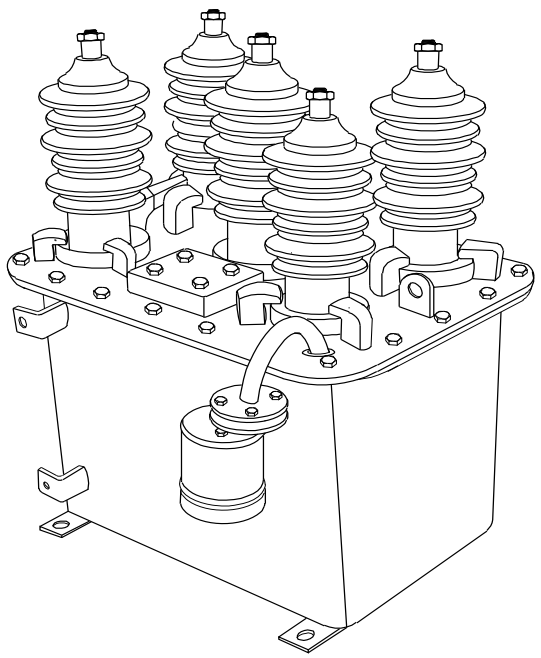
14 Conduct functional tests to ensure the CT/PT is operating correctly under load conditions.

15 Conduct a final visual inspection to ensure everything is in order and that all safety measures have been followed.

16 Perform post-maintenance tests to confirm that the CT/PT is operating within acceptable parameters and providing accurate measurements.

Remember that these steps are a general guideline and the specific procedures may vary depending on the manufacturer's recommendations and the type of equipment you are dealing with. Always prioritize safety and follow appropriate industry standards and guidelines.

Fig 1



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Identify various components and their specification

Objectives: At the end of this exercise you shall be able to
- **to identify the various earthing components**
- **to identify various earthing components used in electrical circuits.**

Requirements

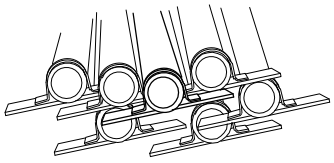
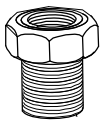
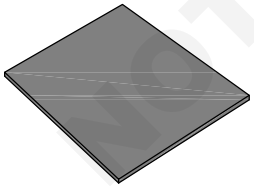
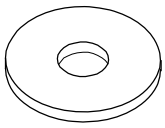
Tools/Instruments

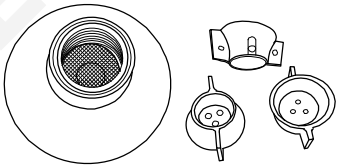
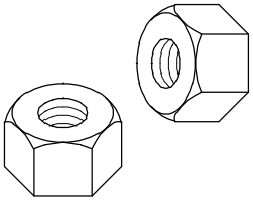
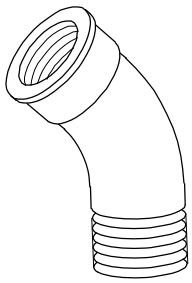
- G.I wire no.8swg
- Copper lug 200A with 1 gmm dia hole - 1 No.
- Cement - 10 gms
- River sand - 80 kg
- Salt - 3 bags
- Coke (or) char coal - 3 bags
- G.I plate 600mm x 600mmx 63 mm - 1 No.
- G.I cover hinged to C.I frame 300 mm square - 1 No.

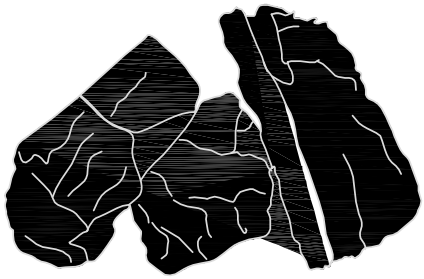
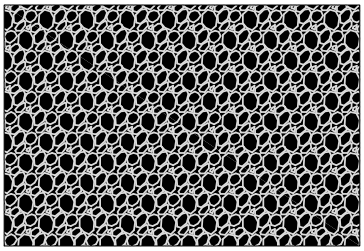
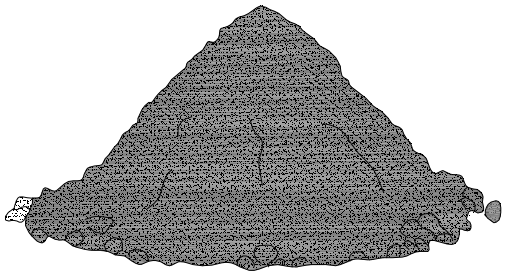
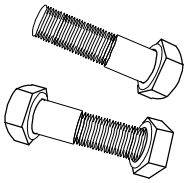
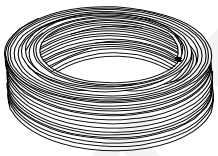
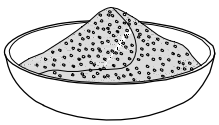
Materials

- G.I bend 12.7 mm dia -2
- G.I pipe 12.7 mm dia -5 metre
- G.I pipe 19 mm dia -1 metre
- G.I pipe 38 mm dia and 12 mm with small holes - 2.5 Mtr.
- Reducer 38x19 mm - 1 No.
- G.I check nut 19 mm dia - 4 Nos.
- G.I check nut 19 mm dia sleeve & wire mash - 1 No.
- G.I check nut 19 mm dia - 4 Nos.
- G.I washer 40 mm with 19 mm dia hole - 1 No.

PROCEDURE

Components	Name and application
 G.I. Pipe with Clamp	
 G.I. Reducer	
 Copper Plate	
 G.I. Washer	

Components	Name and application
 Earthing Funnels	
 G.I. Check Nut	
 G.I. Bend	

Components	Name and application
 Charcoal	
 Concrete small stone	
 Cement	
 G.I. Bolt Nut	
 Earth wire	
 River Sand	
 Salt	

Conclusion: Write the components name and their specification given in tabular column and get approved by the trainer.

Plan and prepare pipe earthing

Objectives: At the end of this exercise you shall be able to
- **prepare the pipe for earthing**
- **dig the pit in the ground**
- **install the earth pipe and test it.**

Requirements

Tools/Instruments

- G.I. die stock with 12.7 mm, 19mm and 38mm dies - 1 Set
- D.E. spanners 5mm to 20mm of six. - 1 Set
- Blowlamp, 1 litre with kerosene - 1 No.
- Crowbar, hexagonal 1800mm long - 1 No.
- Powrah (spade) - 1 No.
- Pick axe - 1 No.
- Cement mortar tray - 2 Nos.
- Tongs 300mm - 1 No.
- Measuring tape 5m - 1 No.
- Ladle - 2 Nos.
- Combination pliers 200mm - 1 No.
- Pipe wrench 50mm - 1 No.
- Hacksaw with 32 T.P.I. blade - 1 No.
- Wooden box 150(l) x 150(b) x 300(h) mm - 1 No.
- Soldering pot (melting) - 1 No.
- Sledge Hammer 2 Kg. - 1 No.

Equipment/Machines

- Earth tester with connecting leads and spikes - 4 Nos. - 1 No.

Materials

- G.I. pipe 12.7mm dia. - 5 m
- G.I. bend 12.7mm dia. - 2 Nos.
- C.I.cover hinged to C.I. frame 300 mm square - 1 No.
- G.I. pipe 19mm dia. - 1 m
- G.I.pipe 38mm dia. having 12mm dia. holes - 2.5 m
- Reducer 38 x 19 mm - 1 No.
- Funnel with 19mm dia. sleeve & wire mesh - 1 No.
- G.I.nut for 19mm dia. sleeve & wire mesh - 1 No.
- G.I. check-nuts for 19mm dia. G.I.pipe - 4 Nos.
- G.I.washer 40mm with 19mm hole - 1 No.
- G.I. wire No.8 SWG - 10 m
- Copper lug 200 amps with 19 mm dia. hole - 1 No.
- Solder 60/40 - 100 gms.
- Matchbox - 1 No.
- Soldering paste - 10 gms.
- Cement - 10 kgs.
- Blue metal chips 6mm size - 40 kgs.
- River sand - 80 kgs
- Salt (common) - 3 bags
- Coke or charcoal - 3 bags

PROCEDURE

1 Collect G.I.pipes and the accessories.

2 Make a slant cut of 30o in the 38mm dia. G.I.pipe to have sharp edge as shown in Fig 1.

3 Make threads in the other end of 38mm dia. G.I.pipe to a length of 25mm.

4 Make threads in both ends of 19mm dia. G.I.pipe to a length of 25mm on one side and 75mm on the other side.

5 Fabricate the 38mm and 19mm dia. G.I.

6 Select an earth pit site atleast 1.5 metres away from the building foundation.

An earth electrode should not be installed in proximity to a metal fence to avoid the possibility of the fence becoming live. If the metal fence is unavoidable, it should be earthed.

7 Dig an earth pit of dimensions 1 m width x 1 m breadth x 3.75 m depth.

8 Place the fabricated pipe in an upright position as shown in Fig 1 and position the pipe with the help of bamboo sticks.

9 Place the wooden box around the pipe and fill it to a height of about 15cm with charcoal, and fill the sorrounding outer space of the box with soil.

It is difficult to dig a pit 150mm square. A pit of dimension 1 metre square is therefore suggested to be dug. The area sufficient to be filled with salt and charcoal is about 150mm square. Hence fill the surrounding extra area with the soil which was taken out earlier.

10 Lift and place the wooden box above the coke layer. Fill up with salt to a height of about 15cm and to an area of 150 x 150mm area around the pipe.

Fill up the surrounding area with soil.

11 Repeat the above steps 10 and 11 up to 2.5 metres.

12 Place the G.I.pipe 12.7 mm dia. meter with G.I. bends in proper position for E.C.C. connection.

13 Prepare the concrete mixture and build the structure.

14 Fix the G.I. cover also.

Atleast allow one day for curing the concrete structure. Pour water every 2 hours. (A wetted gunny sack will hold the moisture for several hours.)

15 Insert the G.I.wire No.8 SWG through the 12.7mm dia. G.I.pipe.

The size of the earth wire depends upon the incoming supply cable size.

16 Use the ladle and the blowlamp and melt the solder.

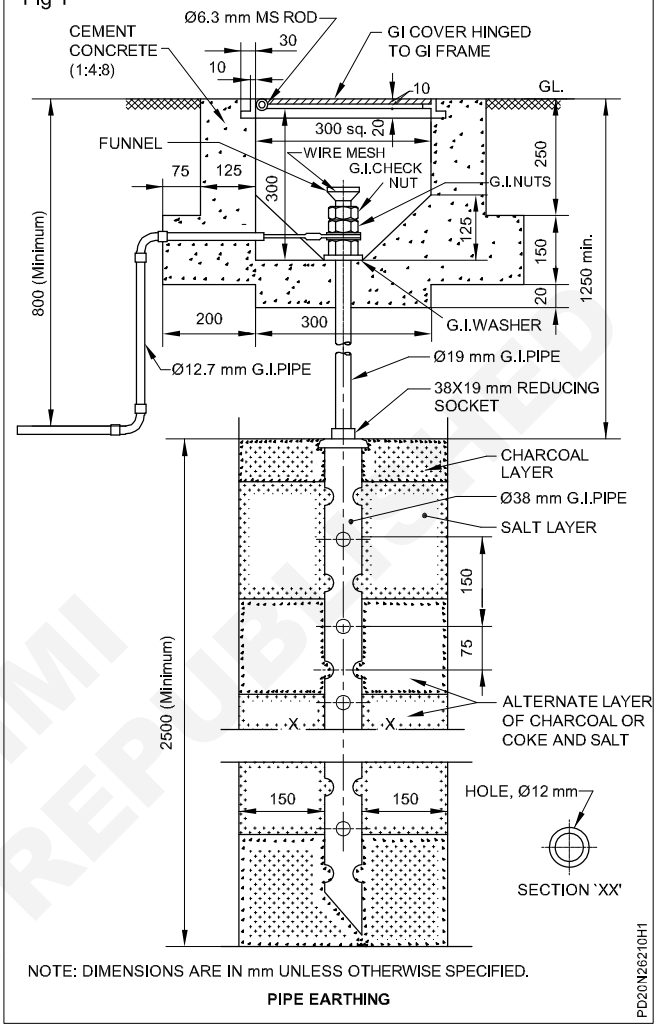
17 Solder the lug in the G.I. wire.

18 Insert the lug in the 19mm dia. G.I.pipe and tighten it with the G.I.nut and check-nut.

19 Pour three or four buckets of water through the funnel.

Allow an hour for the water to be absorbed in the earth.

Fig 1



Plan and prepare plate earthing

Objectives: At the end of this exercise you shall be able to
- **prepare the plate for earthing according to ISI standard**
- **prepare the earthing pit in ground according to required standard**
- **install the plate in earthing pit.**

Requirements

Tools/Instruments

- G.I. die stock with 12.7 mm, 19mm and 38mm die - 1 Set
- D.E. spanner set 6mm to 25mm - 1 Set
- Blowlamp, 1 Pint - 1 No.
- Crowbar38mmx 1800mm long - 1 No.
- Spade 300mm x150mm - 1 No.
- Cement mortar tray - 1 No.
- Tongs 300mm - 1 No.
- Hacksaw frame with 24 TPI blade - 1 No.
- Pipe wrench 50mm - 1 No.
- Soldering pot with ladle - 1 No.
- Combination pliers 200mm - 1 No.
- Measuring tape 5m - 1 No.
- Sledge Hammer 2 Kg. - 1 No.

Equipment/Machines

- Earth tester with spikes and connecting lead - 1 Set

Materials

- G.I. plate 600mmx600mmx63mm - 1 No.
- G.I. pipe 12.7mm dia. - 5 m.
- G.I. pipe 19mm dia. - 1 m.
- C.I.cover hinged to C.I. frame 300mm square - 1 No.
- Funnel with 19mm dia. sleeve & wire mesh - 1 No.
- G.I.nut for 19mm dia. sleeve & wire mesh - 2 Nos.
- G.I. check-nuts for 19mm dia. G.I.pipe - 2 Nos.
- G.I.washer 40mm with 19mm hole - 2 No.
- G.I. wire No.8 SWG - 10 m
- Copper lug 200 amps with 19mm dia. hole - 1 m
- Solder 60x40 - 100gms.
- Soldering paste - 10 gms.
- Matchbox - 1 No.
- Cement - 10 kgs.
- Blue metal chips 6mm size - 40 kgs.
- River sand - 80 kgs.
- Charcoal or coke - 5 kgs.
- CommonSalt - 5 kgs.

PROCEDURE

TASK 1: **Prepare the plate for earthing according to ISI standard**

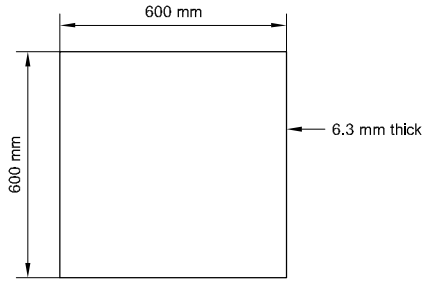
1 Collect G.I plate and accessories for earthing

2 Make thread on one side of 19mm dia GI pipes at a length of 25mm

3 Fabricate GI plate as shown in Fig 1 600mmx600mm square plate with a thickness of 63mm

4 Fabricate 19mm dia G.I pipe as shown in Fig 1.

Fig 1



TASK 2 : **Prepare the earthing pit in ground as per standard**

1 Select an earth pit site atleast 1.5meters away from the building foundation

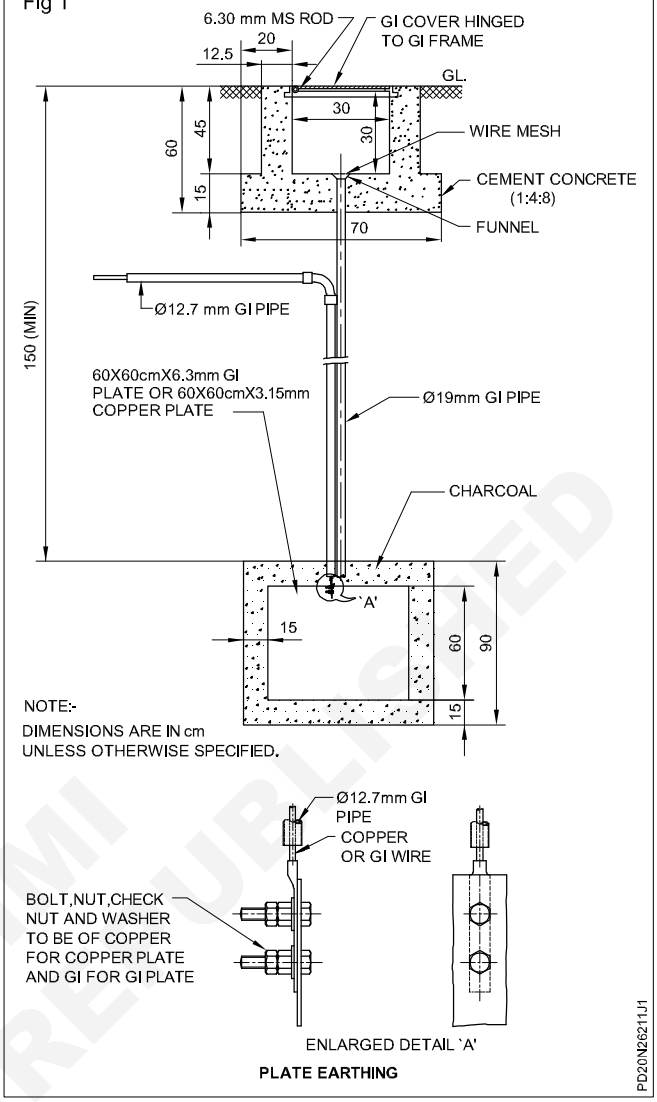
An earth electrode should not be installed is proximity to a metal fence to avoid the possibility of the fence becoming live.

2 Dig an earth pit of dimensions 1m width x 1m breadth x2.5m depth

The depth given here is the minimum recommended. However the depth may be increased till moist soil is reached

3 Fabricate G.I pipe 12.7mm diameter with GI bonds in proper position and insert the G.I wire missing through GI pipe by soldering lug at external and fix GI plate with bolt and nut as shown in (Fig 1)

Fig 1



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TASK 3 : **Install the plate in earthing pit already prepared**

1 Place the fabricated 19mm GI plate in an upright position and position the pipe with the helps bamboo sticks

2 Place the wooden box around the plate and fill it to a height of about 15cm with charcoal and fill the surrounding outer space of the box with soil.

It is difficult to dig a pit 150mm square .A pit of dimension 1 meter square is therefore suggested to be dig. The area sufficient to be filled with salt and charcoal is about 150mm square. Hence fill the surrounding area with the soil which was taken out earlier

3 Lift and place the wooden box above the coke layer and fill up with salt to a height of about 15cm and to an area of 150x 150mm area around the pipe.

Fill up the surrounding area with soil.

4 Prepare the concrete mixture and build the structure.

5 Fix the GI pipe with the plates

At least allow one day for curing the concrete structure. Pour water every 2 hours (A wetted gunny is a act will hold the moisture for several times.

6 Pour three or four buckets of water through the funnel to the earth pit

Allow an hour for the water to be obsorbed in the earth.

— — — — —

Plan and prepare grid/mesh earthing

Objectives: At the end of this exercise you shall be able to
- **plan and prepare of grid/mesh earthing.**

Requirements

Tools/Instruments

- Video project with computer attachment complete set - 1 No.
- Laser pointed pen - 1 No.

Materials

- Chart comprising grid/mesh earthing - 1 No.

PROCEDURE

In substation single-line-to-ground and phase-to-line-to-ground, fault occurs, it will take path through the equipment, incidentally a person touches (or) cross that path, due to resistance, criteria between equipment to earth and person to infinite earth point, he will attain shock it leads to death of person. In end to come over, each substation beneath the earth mesh/grid earthing are properly installed. (Fig 1)

Grid / MESH Earthing

As per figure:

Conductor size In copper: 75 mmx8mm

G.I : 75 mmx10mm

Depth: 8 feet below the ground level and should be constructed as per calculaltion of the size of the yard of substation.

Joints are weld end and connected to the Raiser with suitable Bolt and nut.

(Flat plate)

1 Calculating the size the yard, earth electrode are burned under the earth as per IE rule go around the yard less than 6.0 metre apart to place the grid conductor over the earth electrode

2 Grid conductor are connected to the earth electrode symmetrically.

3 Loose soil layer is filled over the Grid conductors following in evaluated soil are refilled.

Grid /mesh Earthing (step and touch voltage) parameter

a Total length of the conductor in the horizontal grid(m).

b Peripheral length of the grid (m).

c Area of the grid (m²).

d Maximum length of the grid in the ‘x’ direction (m).

e Maximum length of the grid in ‘y’ direction (m).

f Maximum distance between ant two points in the grid(m).

g Spacing between parallel conductor.

h Depth of the ground grid conductor (m).

i Diameter of the grid conductor (m).

j Maximum grid current, A.

k Substation ground resistance (W).

l Soil resistivity (W -m)

(Earthing) (Fig 2&3)

Fig 1

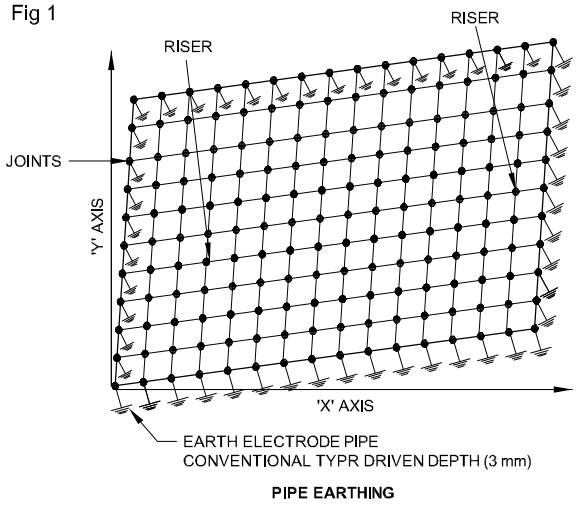


Fig 2

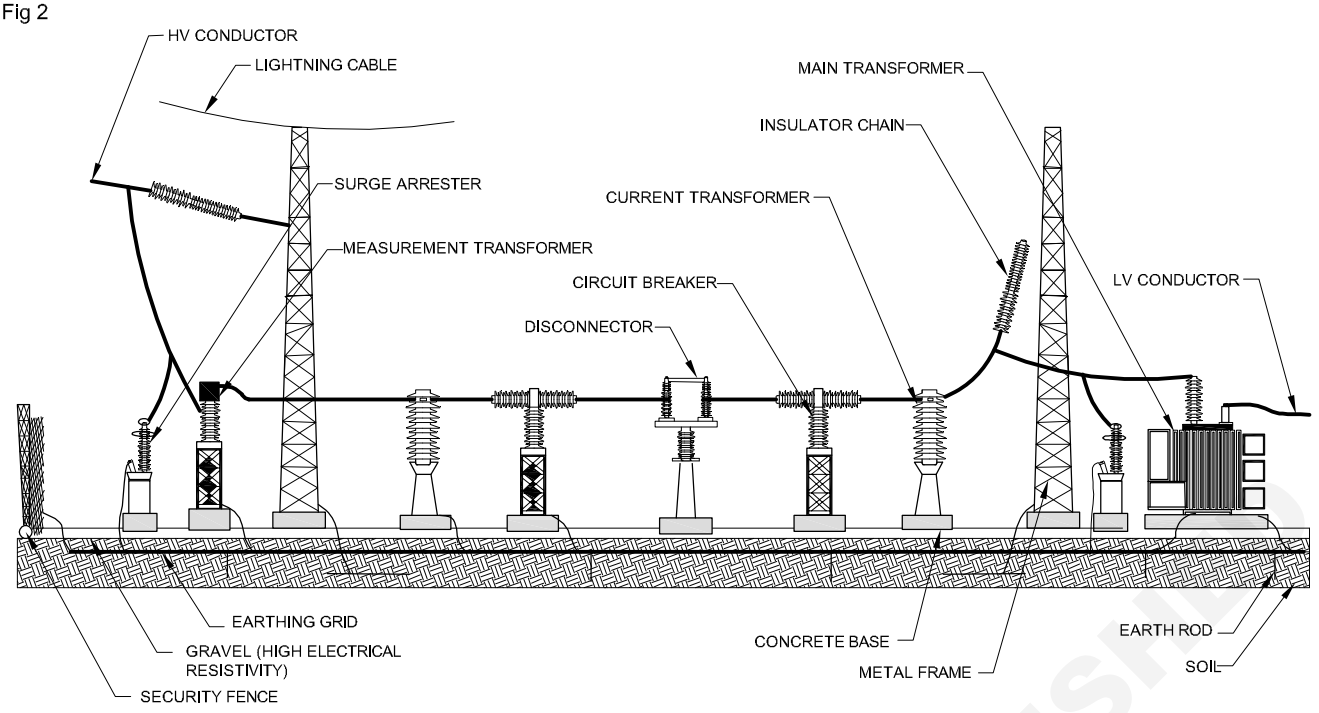
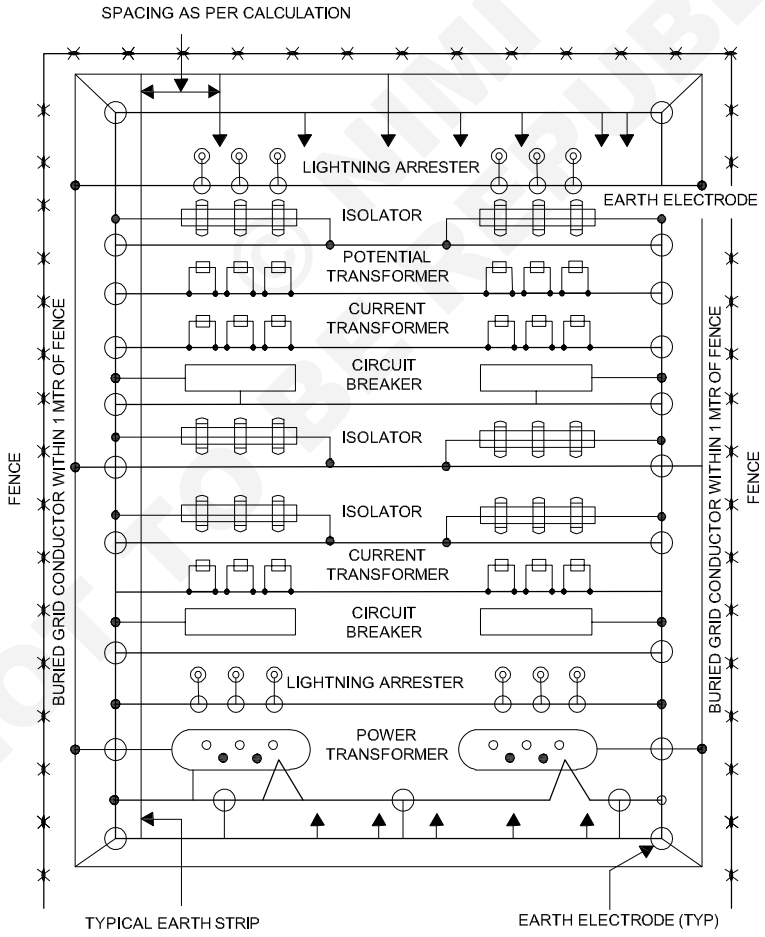


Fig 3



Practice earthing of delta connected system

Objectives: At the end of this exercise you shall be able to
- **prepared earthing of delta connected system.**

Requirements

Tools/Instruments

- GI die stock with 12.7 mm, 19mm and 38mm dies - 1 Set
- DE spanners 5mm to 20mm of six - 1 Set
- Blowlamp. 1 litre with kerosene - 1 No
- Crowbar hexagonal 1800mm long - 1 No
- Powrah (spade) - 1 No.
- Pick axe - 1 No
- Cement mortar tray - 2 Nos
- Tongs 300mm - 1 No.
- Measuring tape 5m - 1 No
- Ladle - 2 Nos.
- Combination pliers 200mm - 1 No.
- Pipe wrench 50mm - 1 No
- Hacksaw with 32 TPI blade - 1 No
- Wooden box 150(1) x 150(b) x 300 (h) mm - 1 No.
- Soldering pot (melting) - 1 No
- Sledge Hammer 2 Kg - 1 No.

Equipment/Machines

- Earth tester with connecting leads and spikes - 4 Nos - 1 No

Materials

- GI pipe 12.7mm dia -5m
- GI bend 12 7mm dia - 2 Nos
- CI cover hinged to CI frame 300 mm square -1 No
- GI. pipe 19mm dia - 1 m
- GI pipe 38mm dia having 12mm dia holes -25m
- Reducer 38 x 19 mm - 1 No
- Funnel with 19mm dia, sleeve & wire mesh - 1 No
- GI nut for 19mm dia sleeve & wire mesh -1 No
- GI check-nuts for 19mm dia GI pipe - 4 Nos
- GIwasher 40mm with 19mm hole - 1 No.
- GI wire No 8 SWG - 10 m
- Copper lug 200 amps with 19 mm dia hole - 10 m
- Solder 60/40 - 100 gms
- Matchbox - 1 No
- Soldering paste - 10 gms
- Cement - 10 kg
- Blue metal chips 6mm size - 40 kg
- Riversand - 80 kg
- Salt (common) - 3 bags
- Coke or charcoal - 3 bags

PROCEDURE

Earthing a delta-connected system is crucial for ensuring safety and proper functioning.

Before starting any work, make sure the power supply to the system is turned off and proper safety measures are in place.

1 Choose suitable earthing electrodes.

2 Install the earthing electrodes.

3 Connect one end of the earthing electrodes to each of the delta points of the system.

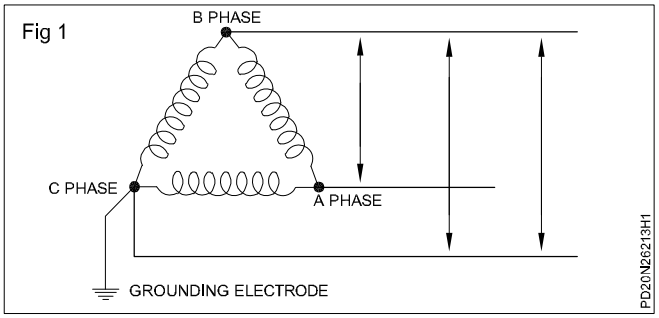
4 Interconnect all the earthing electrodes using conductors to ensure a low- resistance path for fault currents.

5 Dig earth pits near each earthing electrode, ensuring they are of sufficient depth and size according to local regulations. Line the pits with suitable materials like charcoal and salt to improve conductivity.

6 Connect the other end of the earthing electrodes to the earthing pits using earthing conductor.

To follow local regulations, codes, and standards when designing and implementing earthing systems for delta-connected systems to ensure safety and compliance.

Fig 1



Practice grounding of equipment and system

Objectives: At the end of this exercise you shall be able to
- **list the required material for equipment earthing.**
- **practice in equipment earthing**
- **list the required material for system grounding**
- **practice in system grounding.**

Requirements

Tools/Instruments

- Combination plier 200mm - 1 No.
- Screw drive 150 mm - 1 No.
- D.E. spanner set (6.32 mm) - 1 No.
- Hammer 200 gram - 1 No.
- Electric drilling machine 13 mm - 1 No.

Materials

- Bare copper conduct or 8 swg - 4 Nos.
- 12.5 mm G.I pipe - 5 mt.
- 12.5 mm G.I bend - 2 Nos.
- 4 mm Copper lug - 2 Nos.
- Earth clamp (copper) - 6”x1” - 2 Nos.
- Bolt & Nut 10 mm - 10 Nos.
- Aluminium lug 2.5 mm - 6 Nos.
- G.I Bare conductor 14 SWG - 20mts
- PVC pipe 19 mm - 20 mts
- G.I clamp 19 mm - as reqd
- Wood plug or Archer (or) Fisher - as reqd
- Wood screw 35 mm x 8mm - as reqd
- PVC ‘L’ bow 19 mm - as reqd

PROCEDURE

TASK 1: **Practice in system earthing**

1 As shown in (Fig 1) collect the required Instrument, tools and material

2 Evaluate the cases for 6 inch to fix the G.I pipe.

3 Run the 8 SWG copper base conductor into the G.I pipe 12.7 mm as per the measurement in (Fig 1).

4 Lay the G.I pipe in the trench and connect the earth --- conductor with the clamp of earth electrode.

5 Refill the French with connect plaster.

6 Connect the ECC to the main system. Earth clamp of size 6”x1”.

If needed connect the Earth electrode with the water pipe if it in conduct G.I pipe

7 Check the Earth value by using megger.

8 Get approval from the Instructor.

9 As per (Fig 2) according to the measurement collect the required material and tools Instrument.

10 Cut the PVC pipe of size 19 mm according to the measurement in (Fig 2).

11 Mark the area of the pipe flow with equal distance make 6 mm drill sale for clamp.

12 Plug the wood on hole with hammer.

13 Push the 14 SWG G.I bare conductor into PVC pipe

14 Clamp the PVC pipe in the wall with 35 mm x8mm wood screw with screw driver.

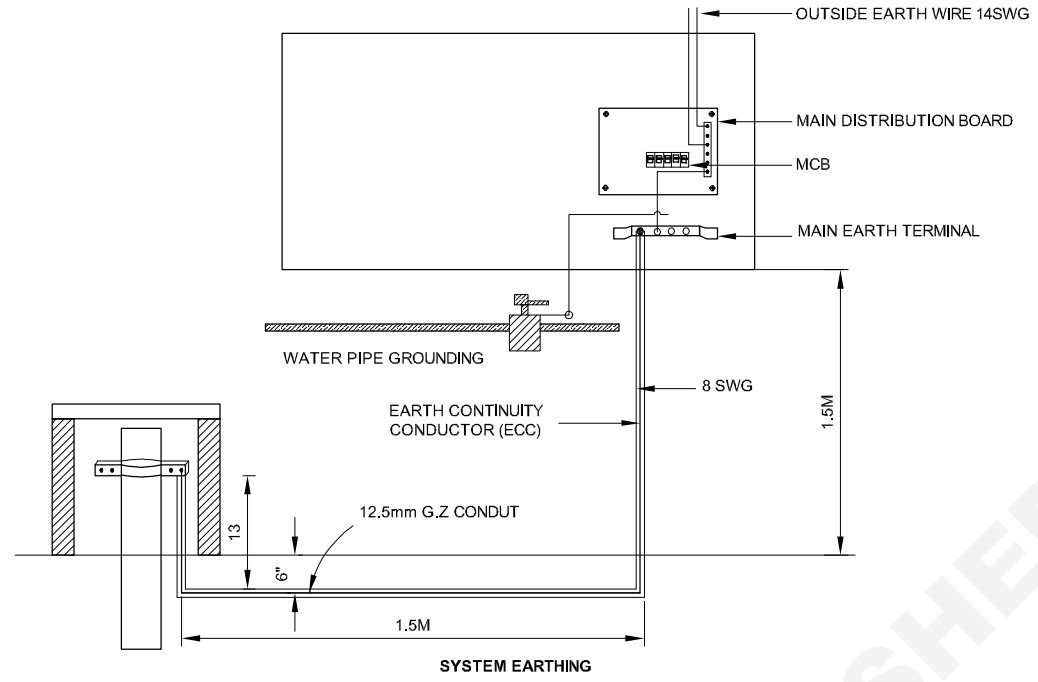
15 Crimp 4 mm lug at two and of the 14 SWG conductor

16 Connect the one end of lug terminal to equipment and another end to the system everything.

17 Check the continuity with megger.

18 Get approval from the instructor.

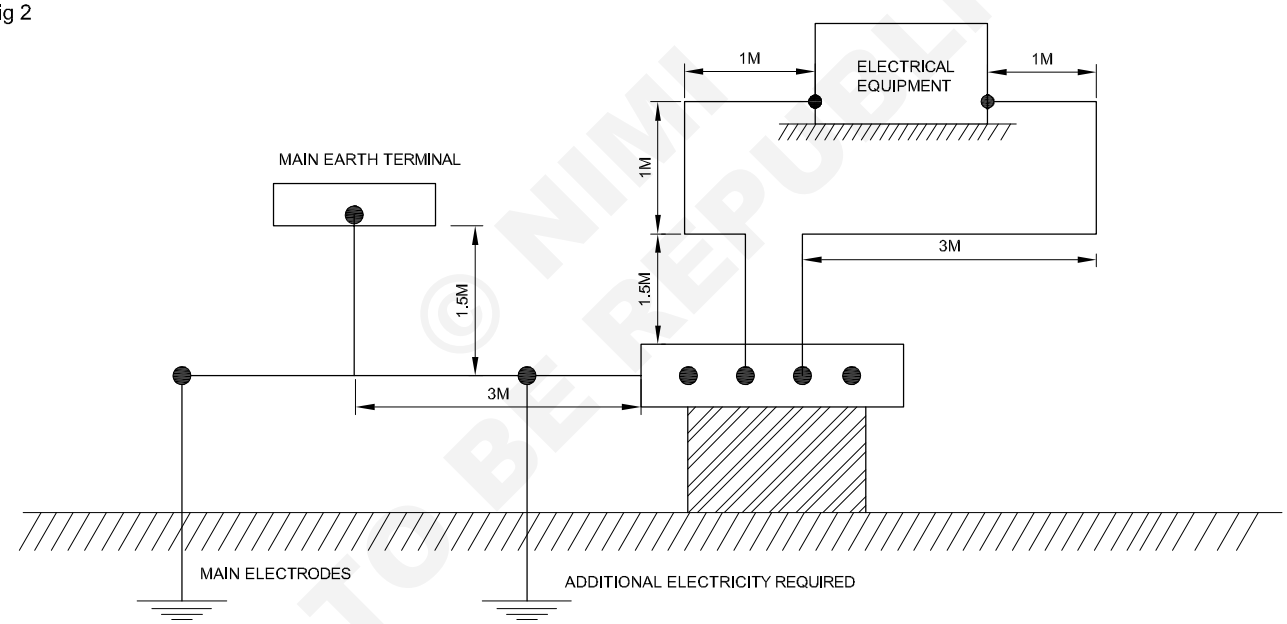
Fig 1



SYSTEM EARTHING

PD20N26214H1

Fig 2



EQUIPMENT GROUNDING

PD20N26214H2

Perform measurement of earth resistance by earth tester

Objectives: At the end of this exercise you shall be able to
- **measure known resistance using three terminal earth tester**
- **measure earth resistance using four terminal earth tester.**

Requirements

Tools/Instruments

- Earth testing 3&4 terminals each - 1 No.
- Metal spikes - 2 Nos.
- Standard cable (preferably the one supplied along with the earth tester) - 3 Set.
- Pipe wrench 250mm long - 1 No.
- Screwdriver 200mm - 1 No.
- Straight pein hammer 1.5 Kg - 1 No.
- Spanner set 5 mm to 20 mm - 1 No.

Equipment/Materials

- Resistors: wire-wound or carbon 2.5 8.2, 10, 12, 100 and 470 ohms of any wattage (Each) - 1 No.
- Plate earthing - 1 No.

PROCEDURE

TASK 1: **To check the accuracy of earth resistance tester with known resistors**

1 Collect the earth tester

2 Note down the name-plate details in Table 1.

Table 1

Type	3 Terminals / 4 Terminals
Range	Single/Multi
Serial No	----------
Accuracy	----------
Rotation speed	----------
Manufacturere	----------
Country	----------

Read and interpret the instruction manual supplied with the earth tester for proper measurement or earth electrode resistance.

The following are the general guidelines for the use of the earth tester in common use.

3 Connect the known resistor 'R' as per circuit diagram in Fig 1.

In the case of a four terminal tester make connections as per circuit diagram - Fig 2.

4 Rotate the generator handle to the required speed unitl the pointer comes to rest.

5 Observe the reading of the instrument in ohms and record in Table 2.

Take care of the range factor in the case of a multi-range earth tester.

Fig 1

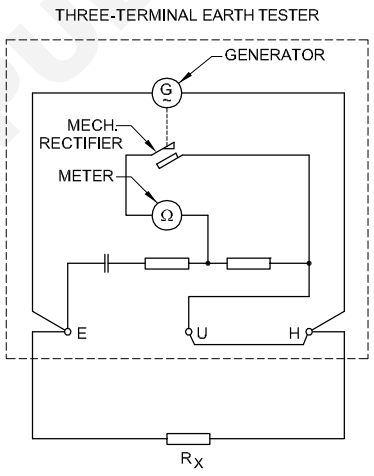
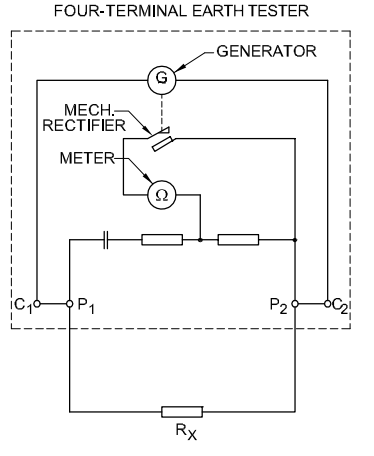


Fig 2



6 Measure atleast four known resistors by following steps No. 3 to 5. Record the values in Table 2.

This measurement exercise is done to check the measurement accuracy of the earth tester. In case of wide variation between the indicated value and the measured value, discuss with the instructor.

7 Show your readings to your instructor for approval.

Table 2

S.No	Readings in ohms	
	Indicated value	Measured value
1 2 3 4		

— — — — —

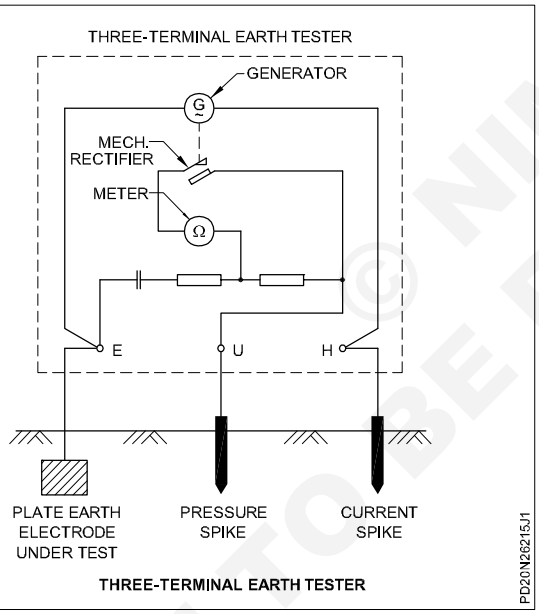
TASK 2: **To check the accuracy of earth resistance tester with known resistors**

1 Drive the metal spikes at a distance of 15 m each from the earth electrode in a straight lines as in Fig 1.

However refer to the instruction manual supplied with the earth tester abd follow the instructions regarding the distance between the spikes and the earth electrode as well as the pattern i.e. straight or equilateral triangle.

2 Connect three terminals of earth tester with the earth plate under test and metal spikes as in Fig 1.

Fig 1



In the case of a four terminal tester make the connection as per circuit diagram (Fig 2).

Use only the accessories (like spike and cables) supplied along with the earth tester by the manufacturer.

3 Rotate the generator handle at the rated speed until the pointer comes to rest.

4 Read the earth electrode resistance from the meter and enter the same in Table 3.

5 Take three more readings by shifting the position of the spikes by 90º around the earth electrode under test as in Fig 3.

If the electrode is near a wall of a building atleast 3 readings could be taken by shifting the spikes at 45º.

6 Select the highest reading out of the set of readings as the actual value of the earth electrode resistance.

7 Show the readings to your instructor and discuss with him the most (suitable protection for the circuit based on the earth electrode resistance.

S. No	Location	Earth electrode resistance in ohms	Actual value electrode resistance (Highest value out of the four readings
1 2 3 4			

Fig 2

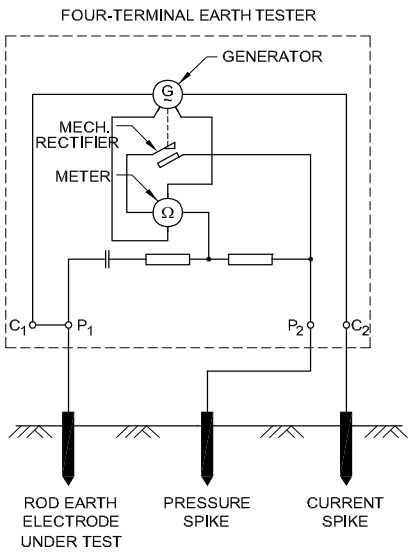
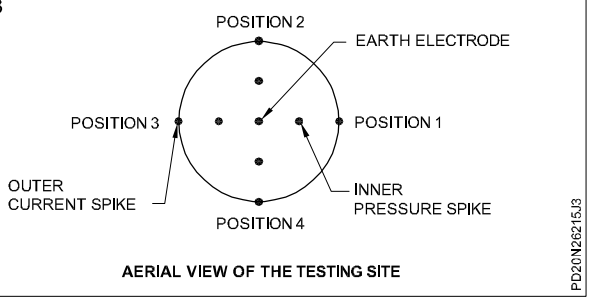


Fig 3



Carryout treatment to minimise earth resistance

Objectives: At the end of this exercise you shall be able to
- **lengthen the earth electrode in the earth**
- **using multiple rod method**
- **treatment of soil using chemical compound.**

Requirements

Tools/Instruments

• Ground rods 2ft 2 nos, 4ft	- 1 No.	• Clamps	-as reqd
• Earth resistance meter	- 1 No.	• Connectors	-as reqd
		• Grounding route sketch	-as reqd

PROCEDURE

TASK 1:

1a, Measure the earth resistance with one electrode driven 2ft down

1b, Measure the earth resistance with same earth electrode driven 4ft down

Note down readings inthe Tabular column no 1Verify the reading by your instructor

Sl. No	ER1.	ER2

— — — — —

TASK 2:

You can find that doubling the rod length will reduce the earth resistance about 40%

2a, Take two electrodes of same size and measure earth resistance with one electrode

2b,Also measure earth resistance with two equal resistance rod

Note down these readings in Tabular coloum 2

attach sketch here

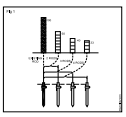
Sl. No	ER1.	ER2

Verify the readings by your Instructor

You can find that reduction for two equal resistance rod is about 40%

If three rods are used, the reduction is 60%

Fig 1



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TASK 3: **Treatment of soil**

Chemical treatment of soil is away to improve earth electrode resistance. When you cannot drive deeper ground rods because of hard underlying rock.

You have to consider the possible corrosive effect. Magnesium sulphate, Copper sulphate and ordinary rock salt are suitable

Note: Chemical treatment is not a permanent way to improve earth electrode resistance

— — — — —

Carryout maintenance of earth system

Objectives: At the end of this exercise you shall be able to
- **electrical continuity checks on joints and conductors by inspection and testing value of earth resistance.**

Requirements

Tools/Instruments

- Electrician's tool kit - 1 No.
- Multimeter - 1 No.
- Earth Tester - 1 No.

PROCEDURE

1 Instructor may take trainees to nearest power station on Maintenance day with permission from Engineer in change, to understand procedure to check main earthing system

2 Follow safety rules and guidelines

3 Obtain drawings relevant to area of all neutral body and structure earth pit & mats

4 Take care due to step and touch potential

5 Do not disconnect more than one earth pit at a time

6 Do not disturb neutral earthpit termination of generator and transformer while in service

Test values are note down and verified by your instructor

S.No	Value of earth resistance measured by Earth tester

Test earth leakage by ELCB and relay

Objectives: At the end of this exercise you shall be able to
- **identify the terminals of ELCB**
- **connect the ELCB in an Power circuit and test its functioning**
- **measure the leakage current at which ELCB trips off.**

Requirements

Tools/Instruments

- Cutting plier 150mm - 1 No.
- Screw driver 150mm - 1 No.
- Electrician's knife 100 mm - 1 No.
- Wire stripper 150 mm - 1 No.
- Ammeter MI (0 - 10A) - 1 No.
- Ammeter MI (0 - 100mA) - 1 No.
- Philips star screw driver 100 mm - 1 No.

Materials

- 10KW 1W wire wound variable resistor - 1 No.
- 5KW 1W fixed resistor - 1 No.
- Pushbutton switch 250V, 6A - 1 No.
- Water rheostat - 1 No.

Equipments

- ELCB 240V, 25A, 2 pole with Tripping leakage current 30mA - 1 No.
- MCB 240V, 10A, 2 pole - 1 No.

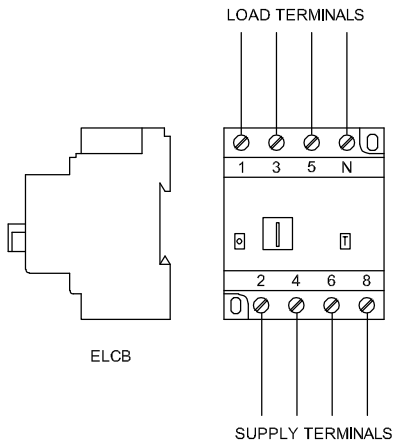
PROCEDURE

TASK 1 : **Identify the terminals of ELCB**

1 Collect the ELCB from your instructor and read the specification given on it.

Identify the supply terminals and load terminals referring the marking on the unit as given in Fig 1.

Fig 1



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TASK 2 : **Connect and test the operation of ELCB**

1 Wire up the circuit as shown in the circuit diagram. (Fig 1)

2 Switch on the main supply keeping the MCB and ELCB in ON position.

3 Close switch S1 and operate the water rheostat till the ammeter 'A' reads about 5 A current.

Keep variable resistance in full cut in position.

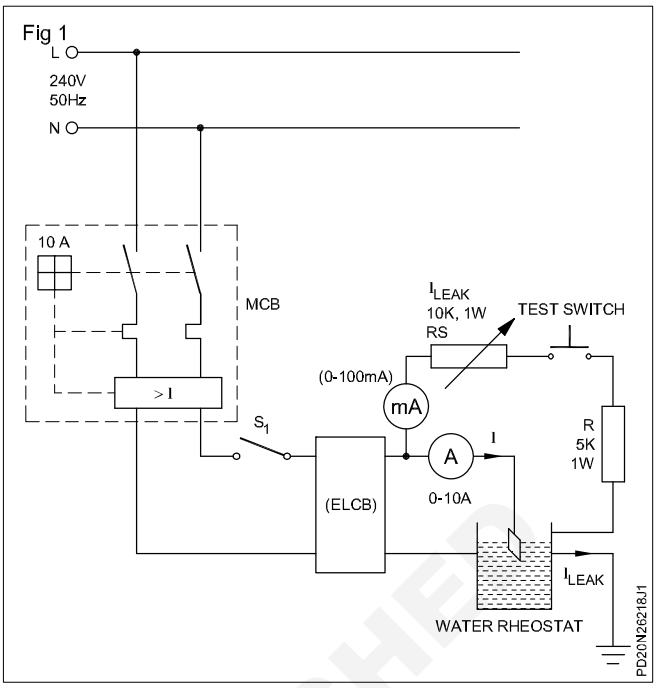
4 Press the test switch and vary the variable resistance and note the leakage current and record _____

5 Record the leakage current at which the ELCB trips off _____

6 Open the external test switch and reset the ELCB.

7 Test ELCB for ‘Trip function’ by operating the ‘Test button’. In this case the ELCB must trip off when the button is pressed.

Fig 1



Identify various conductorsviz., All Aluminium conductor (AAC), ACSR conductor, etc

Objectives: At the end of this exercise you shall be able to
- **identify different types of aluminium conductor and ACSR.**

Requirements

Tools/Instruments

• Standard wire guage	- 1 No.
• Measuring scale	- 1 No.
• AAC (various types)	-as reqd.
• ACSR (various types)	-as reqd.

PROCEDURE

1 Collect piece various types of AAC and ACSR conductor.

2 Take it on workbench and marked alphabet.

3 Take one piece of conductor and count number of strands.

4 Measure the dia. of single strands using standard wire gauge/micrometer.

5 Place magnet near the inner strand.

6 Measure overall dia. of conductor using measuring scale.

7 The given datas are entered in a paper and verified with the standard data.

8 Repeat the exercise one by one again.(Fig 1&2)

Fig 1

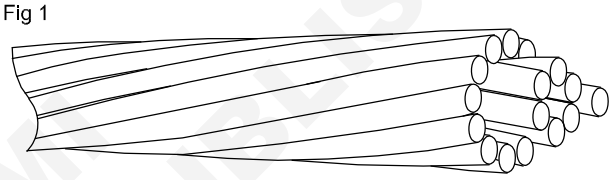


Fig 2

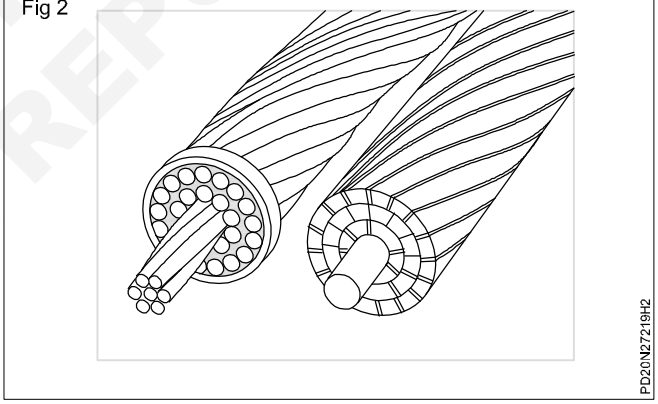


Table 1

Sl. No	Type of conductor	No of strands	dia of strands 10 mm	overall dia (mm) Conduc-tor	Area of Conduc-tor mm²	Breack-ing load in KN	Current capacity in Amps	Vollage range
1	ACSR weasel	7	2.59	7.7	15.30	11.12	144	230 - 440
2	ACSR Rabbit	7	3.35	20.05	50	18.25	157	11000
3	ACSR Raccoon	6	4.09	21	80	22.3	190	11000 - 33000
4	ACSR Dog	6	4.72	1.42	100	32.41	239	33000
5	ACSR Panther	30 ()	3.0	21	200	86.67	395	33000-132 KV
6	ACSR Wolf	30 ()	2.59	18.13	150	67.34	329	33000
7	ACSR Zebra	54 ()	3.18	2.86	420	87.32	737	220 KV
8	ACSR Twin Moose	54 ()	3.53	3.18	520	99.24	896	400 KV

Table 2

Alqhabed Code	No of Strands	Dia meter of strands in mm	overall dia of Conductor	Steel Rein-forced or not	Type of Conductor
A					
B					
C					
D					
E					
F					

— — — — —

Perform mechanical and electrical testing of overhead conductors

Objectives: At the end of this exercise you shall be able to
- **mechanical testing of overhead conductors**
- **electrical testing of overhead conductors.**

Requirements

Tools/Instruments

• Tensile testing machine	- 1 No.	• Clamp/ grip	- 1 No.
• Dynamometer	- 1 No.	• Voltage tester	- 1 No.
• Measuring tape	- 1 No.	• Megohmmeter(Insulation Tester)	- 1 No.
• Standard wire gauge	- 1 No.	• Sample piece of conductor (Various type)	-as reqd.

PROCEDURE

TASK 1: **Testing overhead conductors in an electrical distribution system is essential to ensure their safety and reliability.**

1 Collect the necessary testing equipment, which may include a tensile testing machine, dynamometer, measuring devices, and appropriate clamps or grips.

2 Conduct a visual inspection of the selected conductors to check for any visible signs of damage, corrosion, or wear. If any defects are found, these should be noted.

3 Specimen Length and Preparation: Cut the conductor samples to the required length for testing. The length and diameter of the specimen should conform to relevant standards or specifications.

4 Mounting and Fixturing: Securely mount one end of the conductor specimen to the testing machine while ensuring that the grip or fixture does not cause any damage or deformation to the conductor.

5 Load Application: Gradually apply a tensile load to the conductor specimen using the testing machine. The load should be applied at a constant rate until the conductor reaches its breaking point or until the desired test criteria are met.

6 Data Collection: Throughout the test, record data such as load applied, elongation of the conductor, and any signs of deformation or failure. This data will be crucial for analysis.

7 Failure Analysis: If the conductor does not reach its breaking point during the test, carefully examine any signs of deformation, necking, or other structural changes. Note the load at which these events occurred.

8 Exporting: Document the test results, including load-displacement curves, any observed failures or deformations, and the condition of the conductor after testing. Include all relevant details such as specimen identification and testing conditions.

9 Data Analysis: Analyze the collected data to determine whether the conductor meets the mechanical strength requirements specified in relevant standards or specifications.

10 Safety Measures: After testing, safely dispose of any damaged or failed conductor specimens, and ensure that the testing area is cleared of any potential hazards

11 Report and Compliance: Provide a detailed test report that includes the test procedure, results, and compliance status with applicable standards. If the conductor meets the requirements, it can be deemed suitable for use in the electrical distribution system.

12 Maintenance and Records: Maintain records of the testing process and results for future reference and compliance purposes. Regularly inspect and test conductors to ensure ongoing safety and reliability.

— — — — —

TASK 2 : **electrical testing of overhead conductor**

Visual Inspection:

Examine the overhead conductors for visible signs of damage, corrosion, or wear.

Verify that all connections and hardware are in good condition.

Voltage Measurement:

Use a voltage tester to confirm that the conductor is de-energized and there is no voltage present.

Insulation Resistance Test:

Perform an insulation resistance test using a megohmmeter (insulation tester). This measures the resistance of the insulation to ensure it is not compromised.

Record the insulation resistance values.

Continuity Test:

Conduct a continuity test to verify that there are no breaks or open circuits in the conductor.

Ensure that the continuity test is performed with a low-resistance measurement device.

Insulation Integrity Test:

If the overhead conductor has insulation, perform a dielectric strength or insulation integrity test to ensure the insulation can withstand the specified voltage without breaking down.

Tension and Sag Measurement:

Measure the tension and sag specifications. I the overhead conductors to ensure they are within the design

Use appropriate tools and equipment for accurate measurements.

Corona Discharge Inspection:

Check for corona discharge, which can indicate excessive electrical stress on the conductor and may lead to damage over time.

Address any corona-related issues promptly.

Record Keeping

Document all test results, including the date, location, testing equipment used, and the condition of the conductors.

Keep records for future reference and maintenance planning.

Interpretation of Results:

Analyze the test results to determine if the overhead conductors meet the required standards and specifications.

Identify any issues or anomalies that need immediate attention.

Repairs and Maintenance:

If any defects or issues are identified during testing, schedule repairs and maintenance to address them promptly.

Re-test the conductors after repairs to ensure they meet the required standards.

Re-energization:

Once all tests have been completed successfully and any necessary repairs are made, safely re- energize the overhead conductors while following established safety procedures.

Final Documentation:

Update the records with the results of post-repair testing and any additional maintenance work performed

Annexure.A

Name of the manufacture

1	Sample No	
2	Size of Conductor	
3	Drum No	
4	Material used for the drum	
5	Flange diameter in mm	
6	barrel diameter in mm	
7	Traverse in mm	
8	Flange thickness in mm	
9	bore diameter in mm	
10	nail length in mm	
11	nail circle in nos	
12	nail size in mm	
13	Thickness of barrel end supports in mm	
14	Thickness of barrel end lagging in mm	

15	No of stretchers	
16	Stretchers size in mm	
17	No. of Barrel Bolts	
18	Dis of Barrel Bolts in mm	
19	Size of square washer in mm	
20	Size of spindle plate in mm	
21	Nus of spindle plate bot	
22	Dia of spindle plate in mm	
23	Dia of spindle plate bolt in mm	
24	Thickness of external lagging in mm	
25	Nos of Binders over the external lagging in	
26	Whether the flanges with two or three thick angles	
27	Whether the barrel of the drum is lined with material	
28	Whether water proof material lined external surface	
29	Whether inside of the flanges painted with	
30	Whether the drums is numbered	
31	Whether “rolithis way marked	
32	Whether Manufacturer’s name and address	
33	Type of wire marked	
34	Net weight of wire marked in kgs.	
35	bare weight marked in kgs	
36	Gross weight marked in kgs	
37	Length of conductor or the dummarked	
38	address marked	
39	The year of manufacture	
40	Whether ISI Mark affixed	
41	Whether top Conductor finishing and marked	
42	Whether each end of conductor sealed with security seal	
43	Clearance between top conductor finishing surface and bottom of external lagging in mm	
44	Whether external lagging are closely packed	
45	Whether all metal parts are protected with paint	
46	Whether the top layer of the conductor is wound uniformly forming an even surface at top	
47	Whether the top surface of the water proof paper on the drum s free from folding and unevenness	
48	Whether wood preservative applied	
49	Measured net weight of drum in full shape including conductor and external lagging in kg	
50	Measured weight of drums and conductor without lagging in kg	
51	Measured weight of external lagging in kg (49-50)	
52	Measured weight of empty drum without external lagging in kg	
53	Measured weight of conductor alone (50-52)	
54	Adequate storage facility Protecting from rain water, direct sunlight and surface oil	
55	Test facility to perform test as required by standards	
56	Whether all test equipment are of approved mark and having valid calibration	
57	Whether the product offered ice inspection are it complete shape	
58	Drum selected for weighting selected for strand testing	
59	Total length of conductor on the drum marked	

Specimen of a tested result cannexure

Drum No.	Strand No	Size in M.M.	Breaking load in KN	Resistance at 20°C in ohms/ KM	Warpping	Lay Ratio
Mim: _____		3.35	1.36	-	8 OK 6 OFF	10
Mix: _____		3.38	-	3.265	6 OK	14
R-1159	1	3.36	1.65	3.105	OK	12.62
	2	3.35	1.51	3.103	OK	
	3	3.36	1.59	3.105	OK	
	4	3.35	1.63	3.163	OK	
	5	3.35	1.51	3.152	OK	
	6	3.36	1.58	3.196	OK	
R-1167	1	3.36	1.62	3.105	OK	12.79
	2	3.35	1.58	3.169	OK	
	3	3.36	1.61	3.132	OK	
	4	3.35	1.59	3.059	OK	
	5	3.35	1.63	3.132	OK	
	6	3.36	1.57	3.059	OK	
R-1179	1	3.37	1.52	3.132	OK	12.53
	2	3.35	1.59	3.105	OK	
	3	3.36	1.63	3.175	OK	
	4	3.35	1.58	3.125	OK	
	5	3.36	1.57	3.108	OK	
	6	3.36	1.53	3.132	OK	
R-1194	1	3.35	1.51	3.059	OK	12.89
	2	3.35	1.63	3.135	OK	
	3	3.35	1.59	3.141	OK	
	4	3.36	1.63	3.059	OK	
	5	3.35	1.58	3.163	OK	
	6	3.37	1.52	3.105	OK	
R-1195	1	3.35	1.63	3.163	OK	32.61
	2	3.36	1.57	3.152	OK	
	3	3.35	1.52	3.163	OK	
	4	3.35	1.63	3.125	OK	
	5	3.35	1.59	3.189	OK	
	6	3.36	1.63	3.132	OK	
R-1204	1	3.35	1.59	3.056	OK	12.82
	2	3.35	1.62	3.132	OK	
	3	3.35	1.55	3.089	OK	
	4	3.35	1.59	3.153	OK	
	5	3.35	1.63	3.125	OK	
	6	3.36	1.59	3.056	OK	

Status of Inspected Items:

Out of 22 Drums have been selected at random for acceptance test as per GTP

398/Part-11)Drum no R-1159, # 1167 1170 R1195, R1195 R 1704 R1224 R-1235, 1250 # 1260 R 1280 #1200, R 1299, -1305, 1315, 13:8 #1336. R 1339 R-1354, F R-13491orm ACSR RABBIT) & 07 Drums from ACSA RACCOON bearing Drum No RC-147,RC 163 RC-1/2, RC-378 RC 185.& RC-19 has been selected for acceptance test (FAT) and of Drum respectively R 1194, R-1247(RABBIT) & RC 155 have been selected for rewinding an impection Drums randomly selected and put for rewinding Item ACSR RABBIT 6/1/3.35 mm & ACSR RACCOON 6/1/4.09 mm were tested physically at an por the attached witness test report

Factory Routing Tests

Prem Catles Pvt Ltd Shall submit the routine ces report of all 215(RABBIT) & 66 (RACCOON as per 15:395 Port-) with latest amendments confirming to KSEBL Specification

Factory Acceptance Tests

The witness test/FAT on ACSR RABBIT & ACSR RACCOON has been completed as per the te below The test performed Physically by Mr.Prakash kumar PT Asst Engineer SEB LIVE in accordance with PO, GTP & 15:398 (Part 1) with latest amendments

1 Visual Examination (Rewinding)

2 Dimensional Checks

3 Tensile Test

4 Elongation Test

5 Torsion Test

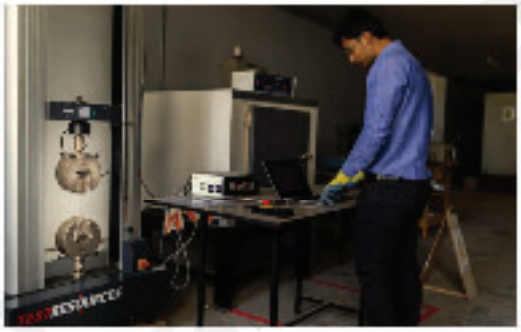
6 Resistance Test

7 Wrapping Test

Zinc coating & Dip Test of Steel Strands

Factory acceptance test reports are attached as Annexure 1 & Annexure-A)

Fig 1



OH Distribution Line, ABC System, HVDS Identify various sizes of copper wires and cable insulation FR/FRLS/FRLSH

Objectives: At the end of this exercise you shall be able to
- **identified different sizes of copper wires.**
- **identified cable insulation.**

Requirements

Tools/Instruments

• Micrometer	- 1No.	• Combination plier	- 1No.
• Manual wire stripper	- 1No.	• Copper wire of Various sizes and Insulation	- as reqd.
• Electrician's knife	- 1No.		

Cable insulation types like FR (Fire Retardant), FRLS (Fire Retardant Low Smoke), and FRLSH (Fire Retardant Low Smoke and Halogen) typically involves checking cable markings, labels, or documentation.

PROCEDURE

The instructor will arrange and provide the Various sizes of copper wire pieces(assorted sizes) on the table label them with alphabets and explain them to trainees, how to identify size os wire, conductors, type of insulation of wires.

1 Take any one wire from the table 1

2 Identify the type of insulation, type of conductor material and size of wires. Note it down in Table 1

3 Skin, clean, straighten and measure the size of conductor using micrometer/standard wire gauge.

4 Take at least five different sizes of wires and repeat step 1 and 2. Note down the details in Table 1

5 Verify the specification of the wire by referring with the data book

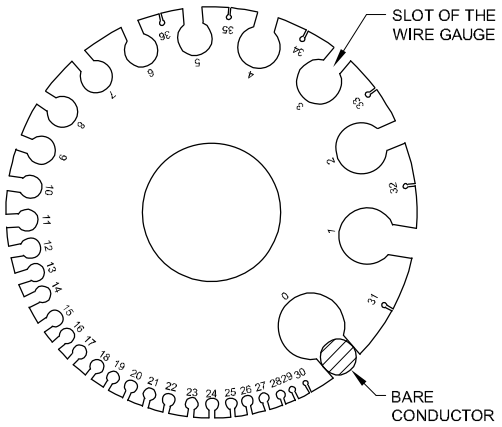
6 Look for markings on the cable itself. Manufacturers often label cables with abbreviations or codes to indicate their properties. FR, FRLS, and FRLSH cables may have these abbreviations printed on the outer jacket

7 Check any documentation or datasheets provided by the cable manufacturer or supplier. These documents usually contain detailed information about the cable's specifications, including its insulation type.

8 Look for certification labels or markings on the cable. FR, FRLS, and FRLSH cables often need to meet specific safety standards. Certifications like UL (Underwriters Laboratories) or IEC (International Electrotechnical Commission) may indicate the cable's fire-retardant and low-smoke properties.

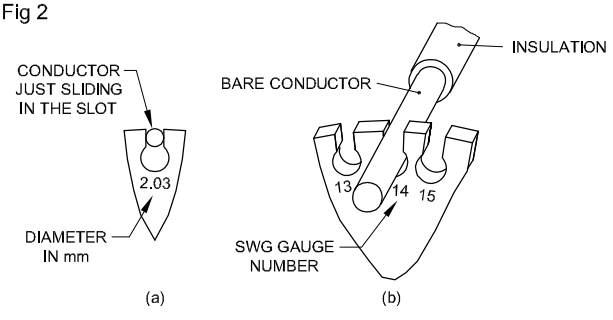
9 Repeat the exercise one by one of given wire

Fig 1



STANDARD WIRE GAUGE

Fig 2



Gauge	Cable/Wire	Diameter	Max Current	Area	Copper Resistance
AWG	Inches	MM	Amperes	MM^2	Ω/KET
1/0	0.3249	8.252	150	53.5	0.09827
1	0.2893	7.348	119	42.4	0.1239
2	0.2576	6.544	94	33.6	0.1563
4	0.2043	5.189	60	21.2	0.2485
8	0.1285	3.264	24	8.37	0.6282
10	0.1019	2.588	15	5.26	0.9989
12	0.0808	2.053	9.3	3.31	1.588
16	0.0508	1.291	3.7	1.31	4.016
18	0.0403	1.024	2.3	0.823	6.385
19	0.0359	0.912	1.8	0.653	8.051
20	0.0320	0.812	1.5	0.518	10.15
21	0.0285	0.723	1.2	0.410	12.80
22	0.0253	0.644	0.92	0.326	16.14
23	0.0226	0.573	0.729	0.258	20.36
24	0.0201	0.511	0.577	0.205	25.67
25	0.0179	0.455	0.457	0.162	32.37
26	0.0159	0.405	0.361	0.129	40.81
27	0.0142	0.361	0.288	0.102	51.47
28	0.0126	0.321	0.226	0.0810	64.90
29	0.0113	0.286	0.182	0.0642	81.84
30	0.0100	0.255	0.142	0.0509	103.2
31	0.00893	0.227	0.113	0.0404	130.1
32	0.00795	0.202	0.091	0.0320	164.11

Table 1

Sl No.	Alphabet	Types of insulation	Type of conductor material	Measured diameter	Area in mm square	Type of wire
1	A					
2	B					
3	C					
4	D					
5	E					
6	F					

Practice joining of Over Head line conductors

Objectives: At the end of this exercise you shall be able to
- **get familiar with different types of Line joints and practice of joining line conductors**
- **acquire knowledge regarding, which types of joint is to be used under which situation.**

Requirements

Tools/Instruments

• Line conductors	- as reqd.
• Splicing Clamps(Connectors)	- as reqd.
• Cleaning material	- as reqd.
• Plier 300mm	- 1 No.
• Sleeve twisters	- 1 No.
• Compression die	- 1 No.
• Sleeves	- as reqd.
• Friction tape	- 1 No.

PROCEDURE

Joining conductors is a practical requirement. It may be required while laying a new power line, because the conductor length on a real may be insufficient to span the total length of the line.Even for an existing line, a break in the conductor may have to be repaired by joining.

Line joints can be divided into three classes Splices, Sleeve joints, and compression joints

Spicing is suitable for small sized copper conductors. But larger sizes of hard drawn copper and Aluminium conductors are usually joined by means of splicing sleeves or compression joints .There is another class of splicing,called automatic spice

In the field the common practice is to use sleeve joints and compression joints to join Over Head lines

Making Spice

Scrape the two end sections of the conductors to be splice and clean with cleanser. The conductors should be cleaned until bright.

Remove all rough or high spots.

Place the cleaned conductors together until approximately 20 to 30 cm (for smaller sizes)/30 to 40 cm (for larger sizes) of the ends overlap each other.

Place splicing clamps (known as connectors) on the two conductors about 10 cm from the end of conductor. See that the connectors grip both the conductor firmly. The conductors should not be allowed to slip or turn in the connectors, otherwise a ‘burned’ conductor will result and one of the conductors will eventually break at that point.

Twist conductors from both ends i.e. wrap each conductor about the other conductor. The usual number of turns to be made is four. More turns may burn the conductor while less may give away and the conductors will crawl apart.

Shift both connectors on to the twisted portion of the conductors. The shift required will be equal to the width of the connector.

With a pair of pliers, finish the splice by serving up the ends. Finishing is done by wrapping the loose ends of the wire about the conductors. Three or four turns are the usual number.

These turns are known as ‘buttons’.

After the buttons are on, the ends should be cut close to the splice.

Solder the Splice.

Wrap the open section with four layers of friction tape and paint with compound if covered wires are used.

Medium-size line conductors are best joined by a splicing sleeve, which is a special connection to ensure good electrical and mechanical joints. The sleeve itself is a piece of single or double tubing. To make a sleeve joint, the procedure is as follows:

Scrape both end sections of the wires clean and bright.

Run wires through sleeves, allowing the ends to protrude,

i.e. the ends of the wires should project about 10-5 cm beyond the ends of the sleeve.

Bend these wires with pliers. This bending keeps them from slipping out of the sleeve.

Make three and a half turns with sleeve twisters, one on either end. Twist lightly.

Cut off the excess conductor beyond the joint on either side and the joint is completed.

Sleeves should be made of the same kind of material as the line conductor. Making a Compression Joint.

Compression joint also makes use of a sleeve. Instead of twisting the sleeve, however, the sleeve is compressed with great force onto the conductor. The use of a die in compression makes the sleeve grip the conductors firmly.

The orders of steps for making a compression joint are as below:

Clean conductor end sections thoroughly. All dirt and grease should be removed with gasoline or similar cleaning solvent. When a conductor that has been in-series, is being spliced, special care should be taken to remove oxidation on that portion which is inserted in the sleeve.

Match the size of splicing sleeve to the size of the conductor.

The die number must be matched to the sleeve number.

The conductor ends must be properly centered in the sleeve.

The specified number of indents must be made.

The joint is ready.

Precaution's

The ends of the wires must be cleaned until they are bright.

Any rough or high spots must be removed.

Connectors should grip the ends of the conductors properly.

Only the require number of turns should be used in twisting.

Shift of connectors should be equal to the width of the connector.

Finishing should be done carefully using plier.(Fig 1&2)

Fig 1

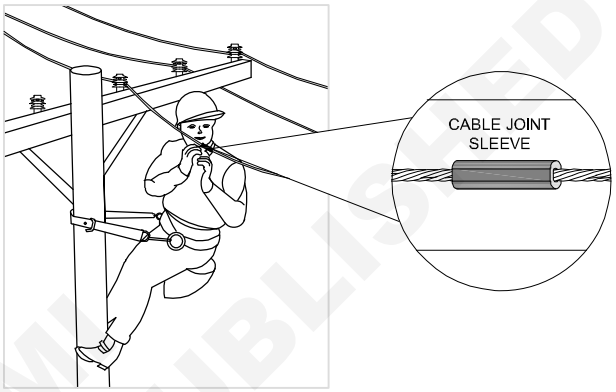
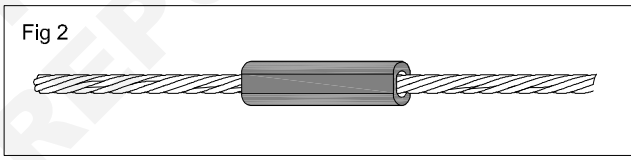


Fig 2



Identify aerial bunched cables used in distribution system

Objectives: At the end of this exercise you shall be able to
- **exercise you shall be able to identify different types of aerial bunched cables used on distribution system.**

PROCEDURE

1 Instructor may callect different sizes of ABC conductor pieces.(Fig 1)

2 Remember the following notes while identify cables.

3 Look at the material used for the conductors.

4 Check the types of insulation used. PVC/ XLPE.

5 Observe the stranding pattern and configuration.

6 Some ABC's have colour coded or marking types of different phases.

7 Determined the voltage ratings.

8 Some ABC's have additional features like water - blocking compounds or UV - resistant coating. (Fig 2&3)

Fig 1

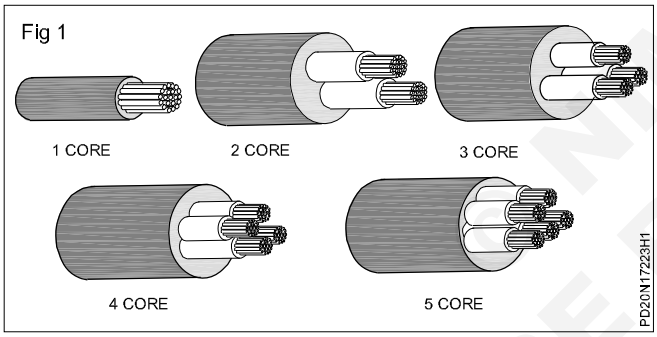


Fig 2

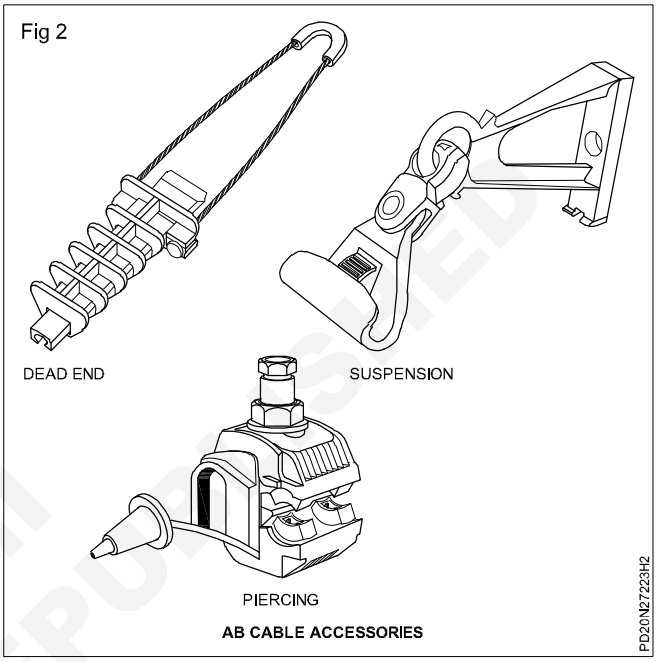
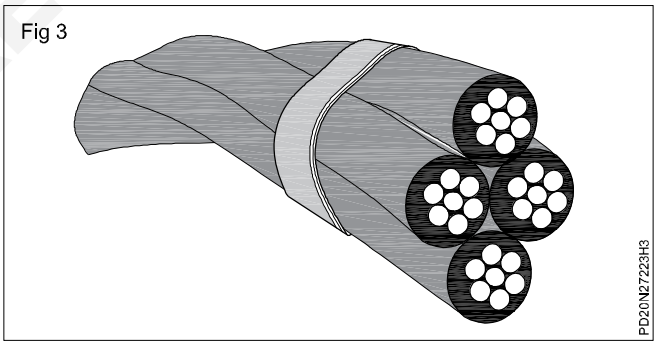


Fig 3



Sl. No.	Alphabet	Type of Insutation	Type of cond material	Area in mm^2	Voltage range	No. of Core	Type of Condmeter
1							
2							
3							
4							
5							

Plan and commission over head distribution line using bare conductors

Objectives: At the end of this exercise you shall be able to
- **exercise you shall be able to**
- **plan, prepare estimate, and commission distribution line by using bare conductors.**

Requirements

Tools/Instruments

- Rope - 25 mts.
- Pulley - 1 No.
- Ladder - 1 No.
- Cutting plier - 1 No.
- Cutter for Conductor - 1 No.
- Helmet - 4 Nos.
- Safety belt - 4 Nos.
- Safety shoe - 4 Nos.
- Adjustable spanner - 2 Nos.

Materials

- PI type 1 to 13 items in material Estimate

PROCEDURE

1 **Regulatory Compliance:** Ensure that your project complies with all local, state, and national regulations, including safety and environmental standards.

2 **Permits:** Obtain the necessary permits and approvals from relevant authorities.

3 **Design:** Develop a detailed design for the OH Distribution Line, ABC System, HVDS, considering factors such as voltage, load requirements, distance, terrain, and environmental impact.

4 **Materials:** Procure the required materials, including bare conductors, insulators, poles, hardware, and safety equipment.

5 **Workforce:** Assemble a skilled and experienced workforce, including engineers, linemen, and support staff.

Procedural Steps

1 **Site Survey:** Conduct a thorough site survey to assess the terrain, existing structures, and potential obstacles that may affect the installation.

2 **Pole Installation:** Set up utility poles at appropriate intervals, ensuring they are properly anchored and meet structural requirements.

3 **Conductor Installation:** String the bare conductors between the poles, taking care to maintain the correct sag and tension. Use appropriate hardware for attaching conductors to insulators.

4 **Insulator Installation:** Install insulators on the poles to provide electrical isolation and support for the conductors.

5 **Grounding:** Implement a robust grounding system to ensure safety and protect against lightning strikes.

6 **Safety Measures:** Enforce strict safety protocols, including the use of personal protective equipment (PPE) and adherence to safety standards for working at heights.

7 **Testing and Commissioning:** Conduct thorough electrical testing, including continuity checks, insulation resistance tests, and voltage checks to ensure the line functions correctly.

8 **Documentation:** Maintain detailed records of the installation process, including drawings, test results, and as-built documentation.

9 **Safety Training: Provide training to all personnel involved in the pro**ject on safety procedures and emergency response.

10 **Environmental Considerations:** Mitigate any potential environmental impacts of the project, such as erosion control and vegetation management.

11 **Maintenance and Monitoring:** Establish a maintenance schedule to inspect and maintain the overhead line regularly, ensuring its ongoing reliability and safety.

12 **Community Outreach:** Communicate with local communities to inform them about the project, address concerns, and establish emergency response plans.

13 **Final Inspection and Approval:** Coordinate with relevant authorities for a final inspection and approval of the OH Distribution Line, ABC System, HVDS.

Keep in mind that the specific steps and requirements may vary depending on local regulations and project-specific conditions. It's crucial to consult with experts in electrical distribution and follow best practices to ensure a successful and safe installation of an OH Distribution Line, ABC System, HVDS using bare conductors.

Fig 1

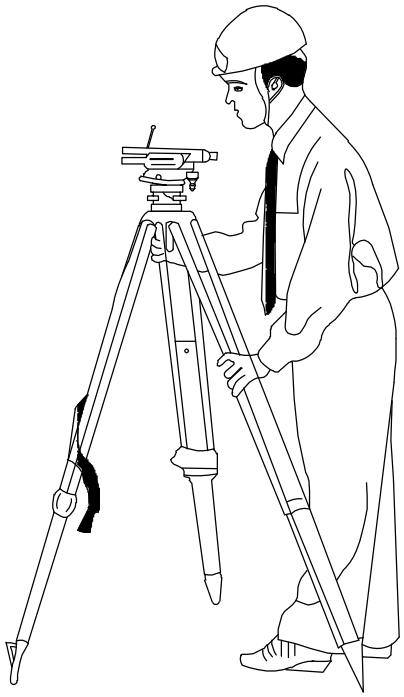


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Fig 2

Fig 3

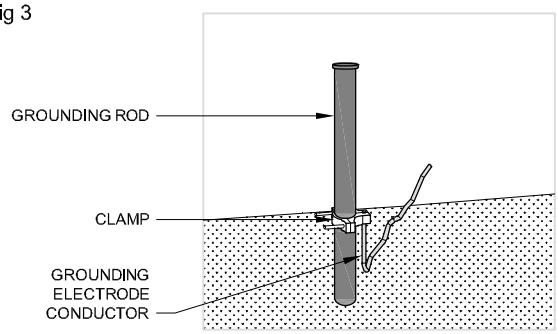

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Fig 4

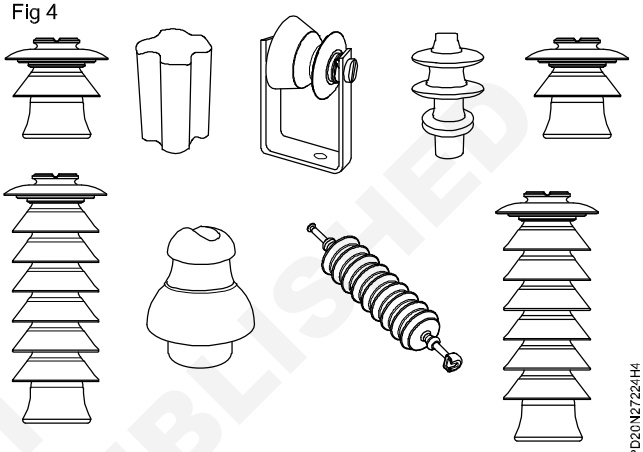

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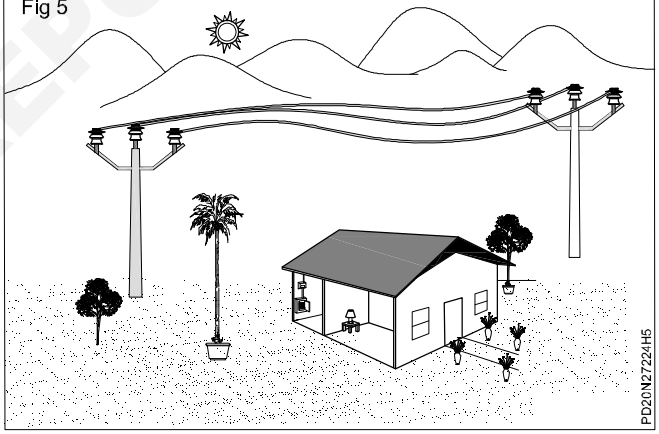
Fig 5



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Statutory clearance from electric line to building

Voltage level	Acrogg any street	along any street	Other area		From building	
			Bare	Insulated	Vertical	Horizontal
	Mtr	Mtr	Mtr	Mtr	Mtr	Mtr
230 & 400 V	5.8	5.5	4.6	4	2.5	1.2
11KV	6.1	5.8	4.6	4	3.7	1.2
22 & 33 KV	6.1	6.1	5.8	-	3.7	2
66 KV	6.1	6.1	6.1	-	4	2.3
110KV	6.1	6.1	6.1	-	4.6	2.8
220 KV	7	7	7	-	5.5	2.8
400 KV	8.8	8.8	8.8	-	7.3	5.8

Name of work: Estimate for constructing LT OH Line of 100m with 4 nos of 8m psc pole under ele section. karaparamba

SL. No.	Name of Materials	Unit	Rate	GST	Qty	Amount
1	PSC pole 8m	E	2704.00		5	13520.00
2	Cross Arm GI 4 line with CBN	E	541.00		4	2164.00
3	Cross Arm GI 2 line	E	210.00		2	420.00
4	Shackle insulator with SBN	E	60.00		8	480.00
5	Pin insulator with pin 415V	E	65.00		8	520.00
6	Packing clamp	E	26.00		8	208.00
7	Stay Rod GI 16mm (LT stay rod)	E	206.00		1	206.00
8	Stay insulator 415V	E	17.00		1	17.00
9	Stranded wire 7/2.5 sqmm (LT stay wire)	Kg	75.00		4	300.00
10	Stay tightener 415V (LT Tum Buckle)	E	143.00		1	143.00
11	Conductor ACSR rabbit	Mtr	34.59		420	14527.80
12	Bolt & Nut 6.5” X 1/2”	Kg	90.00		1	90.00
13	Bolt & Nut 3” X 1/2”	Kg	90.00		1	90.00
	Total					32685.780
	16% of SOC					5229.73
	Total Materials					37915.53

Labour Charges (Part B)

Key	Particulars	Unit	Rate	Add	Qty	Amount
706	Loading LT PSC pole from the stacking place and un-loading the same at work site. (transport by vehicle).	No	319.00		4	1276.00
726	Transporting poles by hired vehicle to a distance upto 726 5km and carrying upto 4 poles excluding loading & unloading.	Trip	1428.57		2	2857.14
204	Erecting one LT PSC Pole in position incl. digging & back filling pit.	No	1342.00		4	5368.00
205	Providing Stay for LT poles incl. digging & back filling pit.	No	625.00		1	625.00
206	Providing Strut using LT PSC pole inch, digging & back filling pil.	No	1256.00		1	1256.00
208	Additional rate for excavation of one Pit for LT Pole/ LT Stay in Laterite.	No	145.00		1	145.00
214	Stringing one km LT 3ph 4 wire line (Rabbit for Ph, Weasel for N) incl. fitting cross arm etc. removing touching and conveyance of materials.	km	212550.00		0.1	2125.00
	Total Labour charge					13652.14
	Super vision Charge 10%					1365.21
	GST of Materials charges 18%					5883.44
	GST of Labour charges 18%					2457.39
	GST of SOC 18%					941.35
	GST of Super vision charge 18%					245.74
	Grand total					62460.88
	Rs.62461/-(Rupees SixtyTwo Thousand Four Hundred and SixtyOne Only)					

Plan and commission distribution line using ABC

Objectives: At the end of this exercise you shall be able to

- **planning and commissioning a distribution line using ABC (Aerial Bundled Cable) involves several steps and requirements.**

Requirements

Tools/Instruments

- Rope - 25 mtr
- Pully Fibre - 4 Nos
- Pully metal - 1 No
- Ladder - 1 No
- SS strap cutter - 1 No
- Cutting plier - 1 No
- Conductor cutter - 1 No
- Safety belt, helmet and safety shoe - 4 Nos

Material

- PSC pale 8 m - 5 Nos
- Aerial bunched cable 120mm^2 110 m 1.1 KV -110m
- Pole clamp - 8 Nos
- S.S strap - 3 mtr
- S.S buckle Slot widlth 20.5 x 1.5 mm thickness 1.2 mm - 8 Nos
- Anchoring dead end clamp for insulated messenger 120 mm^2 - 2 Nos
- Suspension clamp - 3 Nos
- Add item No. 5 to 10 of exercise no. 224
- Bott & Nuts - 2 Kg
- End cap - 10 Nos

PROCEDURE

1 **Project Scope:** Define the scope of the distribution line project, including the area to be covered. voltage levels, load requirements, and any special considerations like environmental or regulatory requirements.

2 **Design and Engineering:** Develop a detailed engineering plan for the distribution line, including the layout, conductor size, insulation type, and support structures. Ensure compliance with relevant standards and regulations.

3 **Materials and Equipment:** Procure all the necessary materials and equipment, including ABC cables, support structures (poles or towers), insulators, connectors, transformers, and protective devices.

4 **Permits and Approvals:** Obtain the required permits and approvals from local authorities, regulatory agencies, and landowners for the installation of the distribution line.

5 **Safety Measures:** Implement safety measures for the construction and operation of the distribution line, including worker safety training, equipment inspection, and emergency response plans.

Procedural Steps

1 **Site Survey:** Conduct a site survey to assess the terrain, environmental conditions, and any potential obstacles or challenges.

2 **Clearing and Preparation:** Clear the right-of-way for the distribution line, removing any obstacles and ensuring a safe workspace.

3 **Support Structure Installation:** Install the support structures (poles or towers) at the specified locations, ensuring they are securely anchored and meet engineering specifications.

4 **Cable Installation:** Install the ABC cables on the support structures, taking care to maintain the required clearances and tension levels.

5 **Connection and Termination:** Connect the ABC cables to transformers, switchgear, and other distribution equipment. Ensure proper termination and insulation.

6 **Testing and Commissioning:** Conduct rigorous testing of the distribution line to ensure it operates safely and efficiently. This includes insulation resistance tests, voltage and current measurements, and fault testing.

7 **Safety Checks:** Verify that all safety measures and protective devices are in place and functioning correctly.

8 **Documentation:** Maintain detailed records of all installation and testing activities, including as-built drawings, test reports, and equipment manuals.

9 Training Provide training to personnel responsible for operating and maintaining the distribution line

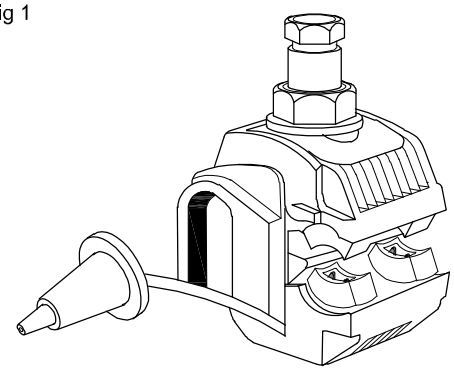
10 Energization Once all tests are successful and approvals are obtained, energize the distribution line, and monitor its performance.

11 **Monitoring and Maintenance:** Establish a regular maintenance and monitoring program to ensure the ongoing reliability and safety of the distribution line.

12 Documentation and Reporting Maintain comprehensive records of maintenance activities, incidents, and any modifications to the distribution line,

It's important to note that the specific requirements and procedures may vary depending on the location, voltage level, and regulations governing distribution line projects. Always consult with relevant authorities and experts in electrical engineering and construction to ensure compliance and safety

Fig 1



IPC FOR ABC 3X95+1X70+1X16 TAP 4-16mm^2

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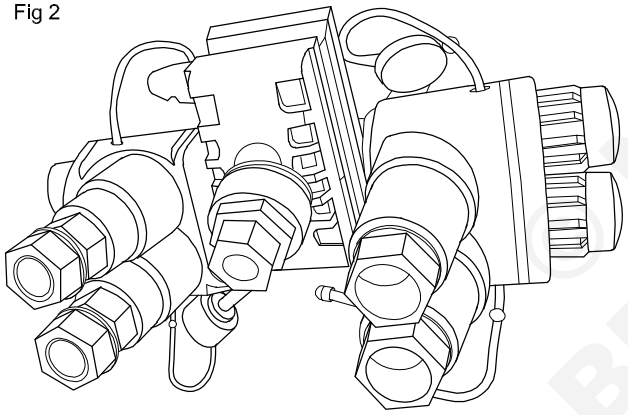
Fig 2



SATELLITE CONNECTOR FOR ABC 3X95 TAP 4-50mm^2

PD20N27225H2

Fig 4

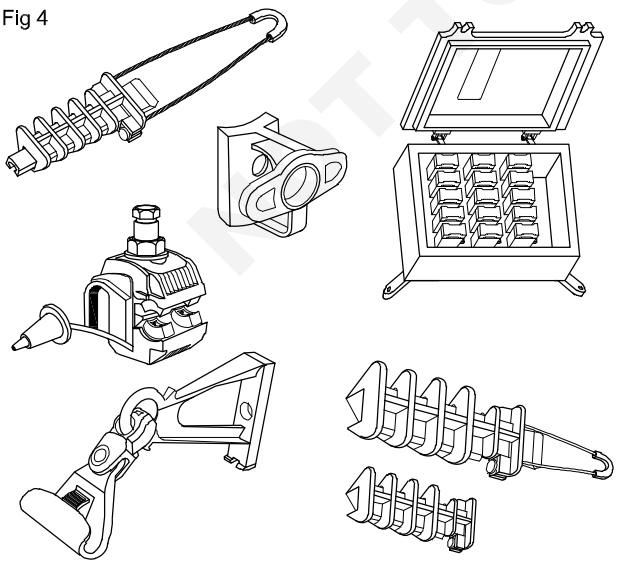


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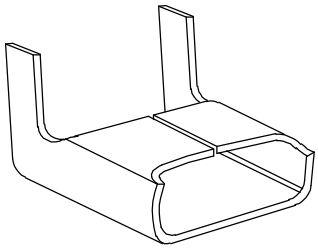
Fig 3



STEEL BUCKLER

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Fig 5

Fig 6

Fig 7

Sl No.	Name of Materials	Unit	Rate	Qty	GST	Amount
1	PSC pole 8m	E	2704.00	5		13520.00
2	Stay rad LI GI (16mm)	E	206.00	3		618.00
3	Stay Insulator 415V	E	17.00	3		51.00
4	Stay wire 7/2.5mm^2 (LI stay wire)	Kg	75.00	12		900.00
5	Stay tightner 4/5V (Turn buckle)	E	143.00	3		429.00
6	Stay block LT	E	205.00	3		615.00
7	B & N 4 x ½ (100 mm x 12 mm)	Kg	90.00	1		90.00
8	B & N 2 x ½ (63 mm x 12 mm)	Kg	90.00	1		90.00
9	Aerial buncked cable 120 mm^2 1.1KV	Mtr	260.00	110		28600.00
10	Pole clamp LI	No	60.00	10		600.00
11	Stainless steel strap	Mtr	60.00	3		180.00
12	Stain less steel buckle slot width 20.5 mm x 1.5 mm thickness 1.2 mm	No	18.00	8		54.00
13	Anchoring/ dead and clamp for insulated messenger 120 mm^2	No	125.00	2		250.00
14	Suspension clamp assembly for LI ABC upto 120 mm^2	No	150.00	3		450.00
15	Insulated piercing conncetor for ABC 120 mm^2 main 16 mm^2 to 120 mm^2, Tap 4 mm^2 to 120 mm^2	No	70.00	10		700.00
16	End cap for ABC	No	20.00	10		200.00
						47347.00
						7575.52
	Total material cost					54922.52
	Labour charge + transportation charge					50000.00
	Supercision charge 10%					5000.00
	G. Total (This estimate not included GST)					1,09,922.52

Identify components and work with high voltage distribution system(HVDS)

Objectives: At the end of this exercise you shall be able to
- **identify components of HVDS**
- **work with HVDS.**

Requirements

Tools/Instruments

- PPE kit - 1No.
- Safety gloves - 1Set.
- Earthing/grounding kit - 1Set.
- Electrician's tool kit - 1Set.
- Safety belt - 1No.
- Helmet - 1No.
- Lock - as reqd.
- Tags(danger board) - as reqd.
- Ladder - 1No.

PROCEDURE

Working with high-voltage distribution systems is extremely dangerous and should only be done by trained and qualified personnel.

1 Ensure that you have the necessary training, qualifications, and personal protective equipment (PPE) for working with high-voltage systems.

2 Always work with a partner, and establish clear communication procedures.

3 Familiarize yourself with the high-voltage distribution system's components, such as transformers, circuit breakers, switches, insulators, and conductors. Know the system's voltage rating and the specific components you'll be working with.

4 Inspect all tools and equipment for damage or defects before use.

5 Use specialized testing equipment to verify that the high-voltage system is de-energized and properly grounded before starting any work.

6 Identify the source of high voltage and isolate it. This may involve opening circuit breakers or switches and locking them out to prevent accidental energization.

7 Ensure that the system is properly grounded to dissipate any residual voltage.

8 Use grounding devices and mats as necessary.

9 Put on appropriate PPE, including voltage-rated gloves, clothing, safety glasses, and a helmet with a face shield.

10 Create a detailed work plan that includes step-by-step procedures and safety precautions. Consider potential hazards and develop contingency plans.

11 Execute the planned tasks while following safety protocols. Always maintain a safe distance from energized components and conductors.

12 After completing the work, use testing equipment to verify that the system is functioning correctly. Ensure that all safety measures are still in place.

13 Only after confirming that the work is completed safely and correctly, remove any lockout/tagout devices. Document the Work.

14 Keep detailed records of the work performed, including any testing results, modifications, and equipment used.

15 High-voltage work should only be performed by trained and qualified personnel under the supervision of experienced professionals.

16 Be prepared for emergencies. Know the location of emergency shutdown switches, first aid equipment, and emergency contact numbers

17 Conduct a final inspection to ensure that the work area is safe and all equipment is properly stored.

18 After completing the work, review the job with your team to identify lessons learned and areas for improvement.

Fig 1

Fig 3

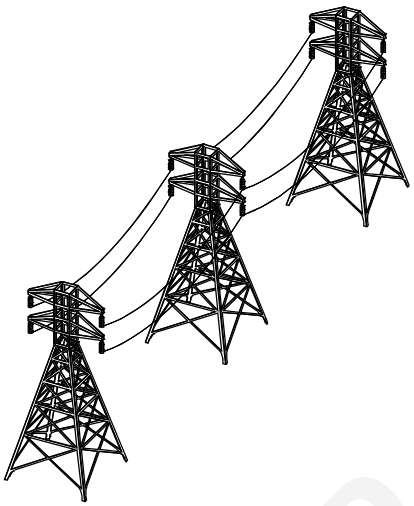

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Fig 5

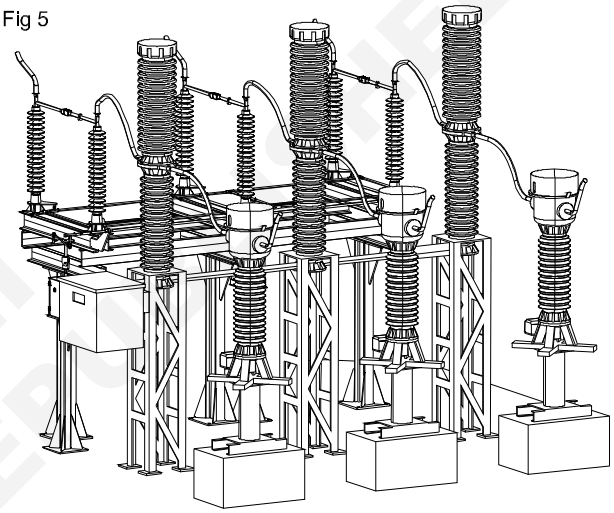

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Fig 2

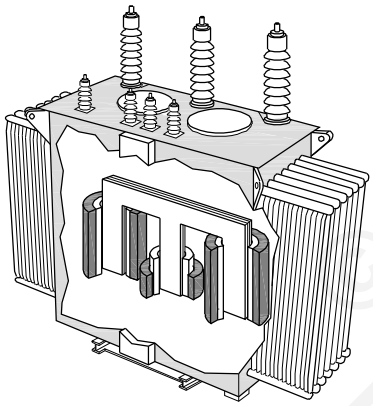

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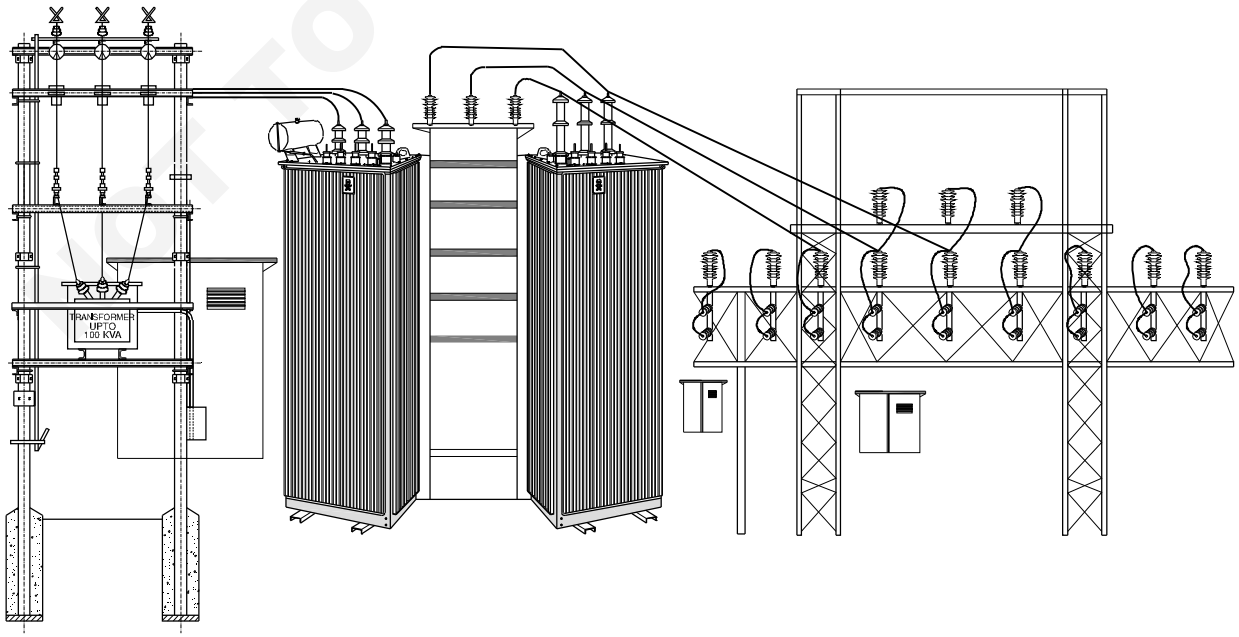
Fig 4



PD20N27226H4

Identify different supports transmission towers and various accessories

Objectives: At the end of this lesson you shall be able to
- **Identify different supports transmission towers and various accessories.**

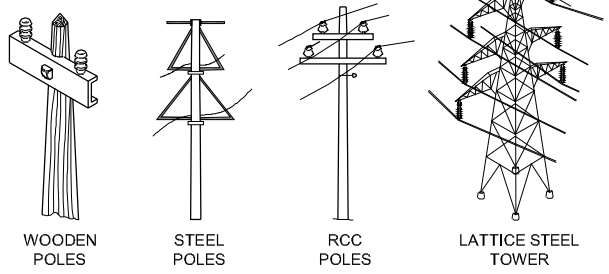
PROCEDURE

1 Instructor visit power distribution site and identified the supports and its accessories, understand them to students.

Types of Line supports

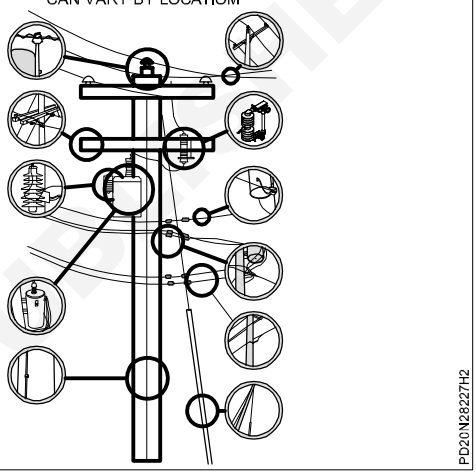
The line supports used for transmission and distribution of electrical power are classified into following types. (Fig 1&2)

Fig 1



- Wooden poles
- Steel poles
- R.C.C. Poles
- Lattice steel towers

Fig 2 WHAT'S ON AN ELECTRIC POWER POLE?
BASIC EQUIPMENT FOUND ON A TYPICAL DISTRIBUTION POLE. CAN VARY BY LOCATIOM



Perform digging of pit, erection of supports and fitting various accessories on poles

Objectives: At the end of this lesson you shall be able to
- **carryout erection of supports and fitting various accessories.**

Requirements

Tools/Instruments

- D.E. spanner set 6mm to 32mm - 1 Set.
- Combination pliers 200mm - 1 No.
- Heavy duty screwdriver 300mm - 1 No.
- Safety belt to work on pole - 1 No.
- Crowbar 2m long 40mm dia - 1 No.
- Spade - 1 No.
- Shovel - 1 No.
- Plumb bob with thread - 1 No.
- Cotton or jute rope 15m long - 1 No.
- Hammer ballpein 500g - 1 No.
- Safety belt - 1 No.
- Bamboo ladder - 1 No.
- Draw pulley - 1 No.
- Aligning rod - 1 No.
- Metal ram - 1 No.

Materials

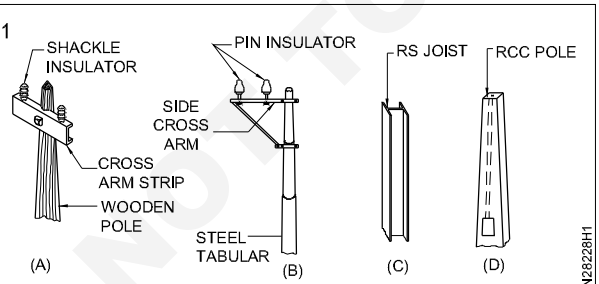
- Wooden/RCC/iron/tubular pole of 6m length - 1 No.
- M.S. angle iron cross-arm 50mm x 50mm x 6mm size suitable for 240V supply line - 1 No.
- 'C' clamp M.S. size as required with nuts, bolts and washers - 2 Sets.
- Country wood plank 2m long, 30cm width 5cm thick - 1 No.
- Cement, sand, blue metal chips etc as per the size of pit - as reqd.
- Stay insulator (egg insulator) - 2 Nos.
- Double screw stay tightener - 2 Nos.
- C.I. stay plate - 2 Nos.
- H.D.G. steel wire (stay wire) 7/16 SWG - 16 m.
- 50 x 12mm size M.S. bolts and nuts with washers - 2Nos.
- Base plate for pole - 1 No
- Casuarina pole of suitable height - 4 Nos.
- Wooden box of suitable size having 2 side openings for concrete pedestal - 1 No.

PROCEDURE

1 Select the place for fixing the pole near the building based on the span.

2 Select the type of pole to be erected (Fig 1).

Fig 1



TYPES OF POLES IN OVERHEAD SERVICE LINE

3 Dig a pit about 1/6th height of the pole having a diameter of minimum 3 times that of the dia of the pole bottom.

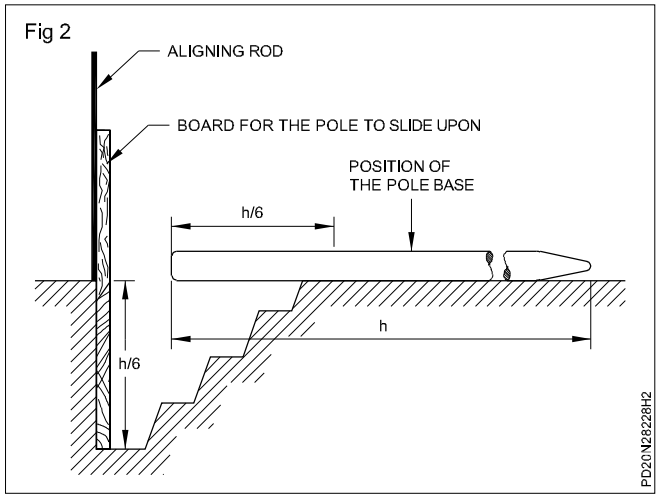
4 Prepare a mixture of concrete having a ratio 1:2:4 (one part cement, two part coarse sand and four part 2 cm blue metal chips) and pour the same in the bottom of the pit to a height of 15cms.

5 Ram the concrete and allow it to settle for a minimum period of 48 hours.

6 Keep the base plate for the pole at the bottom of the pit.

7 Fix a vertical straight pole on the plumb line in the pit Refer (Fig 2)

Fig 2



8 Bring the pole and place it near the pit so that the bottom of the pole is at the edge of the pit.

9 Insert the wooden plank (board) vertically at one side of the pit facing opposite to the bottom portion of the pole.

10 Fix the cross arms at the top of the pole below 30 cm from the top, with the help of 'C' clamps rigidly.

11 Tie the two ropes just below the cross arms.

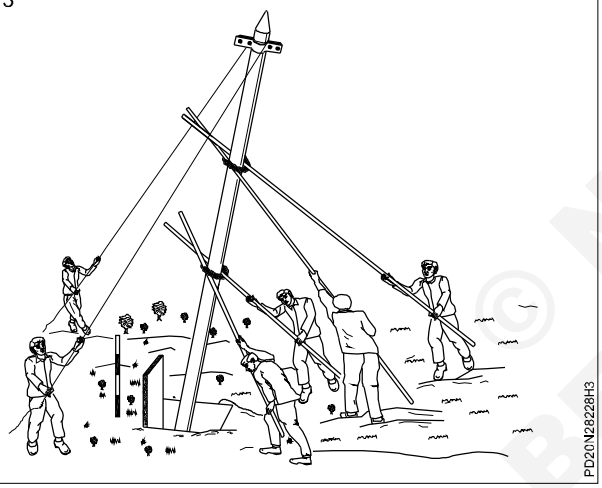
Ensure that the cross arm is in the required direction

12 Place the casuarinas pole at a distance of 1/3 height of the top and also 1/3 height from the bottom of the pole.

13 Prepare concrete mixture in the ratio of 1:3:4 (cement, sand and 1 cm blue metal chips).

14 Lift the pole step by step with the help of a rope and casuarinas pole (Fig 3) and place it on the pit exactly vertical.

Fig 3



15 Check the vertical position with the help of an aligning a rod and plumb bob.

16 Pour the concrete mixture around the pole inside the pit and then place the wooden box around the pole.

17 Pour the concrete mixture in the box to a height of 0.5m above the ground level. Ram the mixture properly.

18 Cure the cement concrete for about 48 hours.

19 Remove the wooden box and plaster the cement concrete above the ground surface to have a smooth finish.

20 Fix the stay rod to the ground at a distance so as to get 45° to 60° between ground level and stay wire should be placed in the opposite direction to the line.

21 Cut the stay wire into 2 pieces of equal length.

22 Fix one end of each piece of the stay wire to the strain insulator (egg insulator).

23 Fix the other end of the second piece of stay wire to the stay. Tighten using a thimble.

24 Fix the stay and tighten to the stay.

Assuming the stay rod is fitted to the ground through a concrete structure which was sufficiently cured.

25 Tighten the stay tightener nut till there is no sag in the stay.

After drawing the overhead lines the stay should be tightened to compensate the tension of the overhead lines and to keep the pole in the vertical position.

Perform stringing and sagging of line conductors

Objectives: At the end of this lesson you shall be able to
- **perform stringing and sagging of line conductors.**

Requirements

Tools/Instruments

- PPE set
- Stringing machines
- Tension measuring device
- Pulleys
- Insulators

PROCEDURE

1 Site preparation

- Identify the route and location where the conductors will be strung.
- Clear any obstacles or vegetation that may obstruct the path.
- Set up a safe work zone and mark it with appropriate warnings signs.

2 Stringing Machine setup

- Position the stringing machine at the starting point of the conductor route.
- Ensure the machine is in good working condtion, properly anchored, and calibrated.

3 Stringing Conductors

- Attach the leading end of the conductor to the pulling eye of the stringing machine.
- Use a pilot line or messenger line to pull the conductor through intermediate pulleys and tensioners along the route.

4 Tensioning

- Apply tension to the conductor gradually and according to the manufacturer's specifications.
- Use tension measuring devices to ensure proper tension is maintained.

5 Sag calculation

- Calculate the sag of the conductor based on factors like span length, conductor type, temperature, and wind conditons. This ensures the conductor's safe clearance from the ground and structures.

6 Sagging

- Adjust the height of pulleys or sheaves to acheive the calculated sag.
- Monitor and make adjustments as needed during the process to maintain the correct sag.

7 Clipping and insulation

- Install insulators, clamps, and connectors as per the design specifications.
- Ensure proper spacing and clearances between conductors and support structures.

8 Testing and inspection

- Conduct electrical testing to verify the integrity of the conductor.
- Inspect all connections, hardware, and insulating materials for defects or damage.

9 Documentation

- Maintain detailed records of the stringing and sagging process, including sag calculations, tension measurements, and any issues encountered.

10 Safety measures

- continuously monitor safety throughout the operation.
- Be prepare to halt work in adverse weather conditions or if safety concerns arise.

11 Cleanup

- Remove any debris or equipment from the work area.

Fig 1

Fig 2

- Ensure the site is left in a safe and clean condition.

12 Final Inspection

- conduct a final inspection to confirm that all work has been completed according to specifications and safety standards.

Following these requirements and procedural steps is crucial for the safety and efficient stringing and sagging of line conductors in overhead power transmisson projects. Always adhere to safety protocols and industry regulations throughout the process.

Fig 3

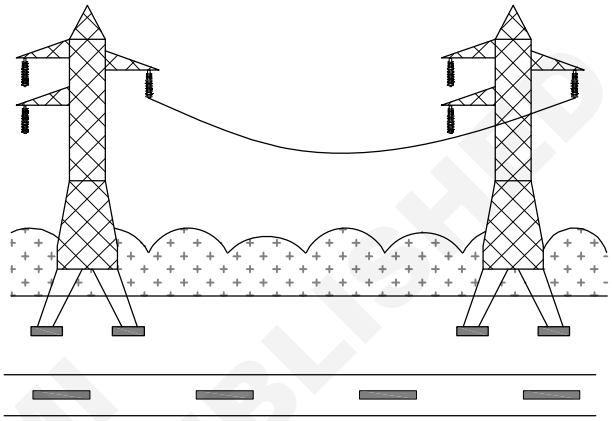
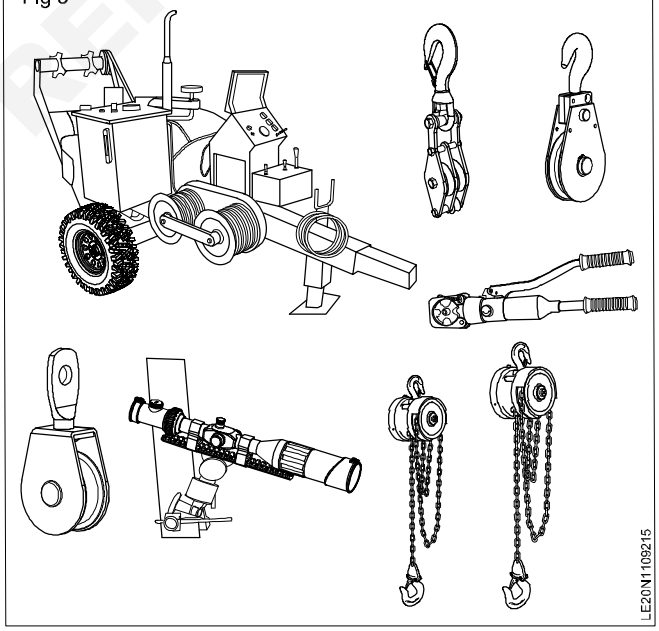


Fig 5



Fasten, jumper in pin, shackle and suspension type insulators

Objectives: At the end of this lesson you shall be able to
- **select the pin type, shackle type and suspension type insulators**
- **fasten jumper in cross-arm of pole with pin insulator**
- **fasten the jumper in shackle type insulator**
- **fasten the jumper in suspension type insulator.**

Requirements

Tools/Equipment /Material

- Insulated combination plier 200mm - 1 No.
- DE spanner set 6 to 25mm - 1 Set
- Adjustable spanner 25mm - 1 No.
- Wooden or nylon mallet 1/2kg - 1 No.
- Ladder 6m long - 1 No.
- Wire stripper 150mm - 1 No.

Material

- Suspension type insulator - 2 Nos.
- Shackle type insulator - 2 Nos.
- Pin type insulator - 2 Nos.
- Flat aluminium tape - as reqd.
- Binding wire 14 SWG aluminium - 5m
- ACSR conductor - as reqd.
- Safety belt - 1 No.
- Clamp - as reqd.
- Nut and bolt - as reqd.

PROCEDURE

TASK 1 : **Fasten the jumper in pin insulator**

1 Keep the ladder on the pole and ask the helper to hold the ladder. climb up the ladder with the guide rope and spanner set.

2 Fix the pin type insulator to the cross-arm of the existing pole.

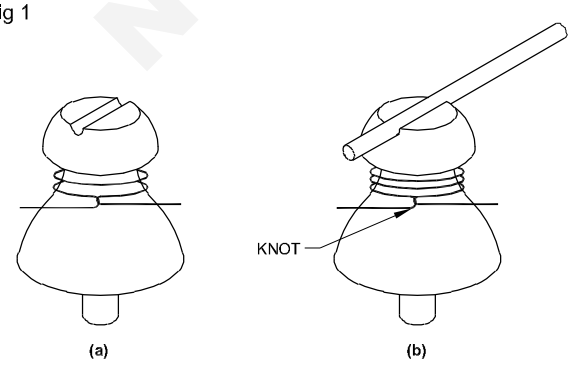
3 Tape the neck of the pin insulator with flat aluminium tape.

4 Lift the Aluminium Contactor Steel Reinforced (ACSR) conductor and keep it in between pole and the pin insulator.

5 Lay the ACSR wire on the slot of the pin insulator and ask the other helper to stretch the conductor with a wire stripper.

6 Take the binding wire of about 2 metres length, leaving equal length on both sides. Bind two turns on the insulation (Fig 1a) around the neck of the pin insulator.

Fig 1

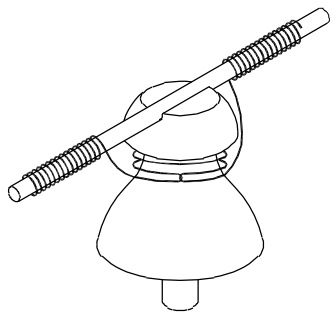


7 Make a knot of the binding wire with the free ends tightly. (Fig 1b)

Binding should have mechanical strength.

8 Bind the free ends of the binding conductor over the line conductor tightly in the opposite direction. (Fig 2)

Fig 2



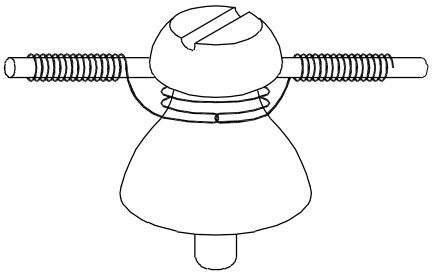
Binding should be tighten without any gap.

Where deviation or bend comes the ACSR conductor bind on the neck of the pin insulator. (Fig 3)

9 Complete the binding by giving about 15 turns on both sides.

10 Cut the extra binding wire and round off the raised ends.

Fig 3



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TASK 2 : **Fasten jumper in shackle insulator**

1 Keep the ladder on the pole and ask the helper to hold the ladder. Climb up the ladder with the guide rope and spanner set.

2 Fix the shackle insulator to the cross-arm with 'C' clamp.

3 Tape the ACSR conductor with flat aluminium tape where it touches the insulator.

4 Ask the helper to properly tie the O.H. conductor to the rope and lift the conductor to the cross-arm position.

While tying the conductor to the rope the helper should leave atleast 1 metre length of conductor free at the end for binding.

5 Insert the conductor around the groove of the insulator leaving half metre at the end. (Fig 1a & 1b)

6 Bind the ACSR conductor with 14 SWG aluminium binding wire tightly (Fig 2a) about 100 to 150 mm approximately.

7 Bend the end of the ACSR conductor in Fig 2(b). and complete the binding work .

Ground clearance of overhead conductor should not be less than 4.572 M for low and medium voltage.

Fig 1

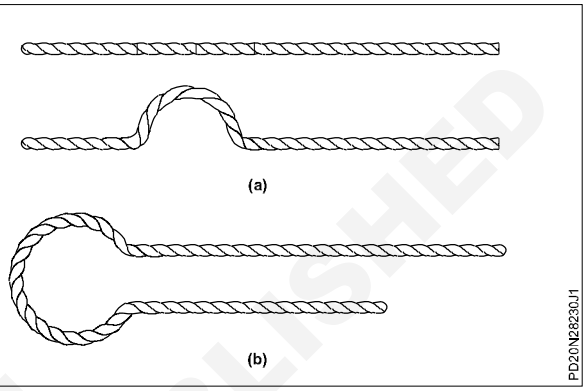

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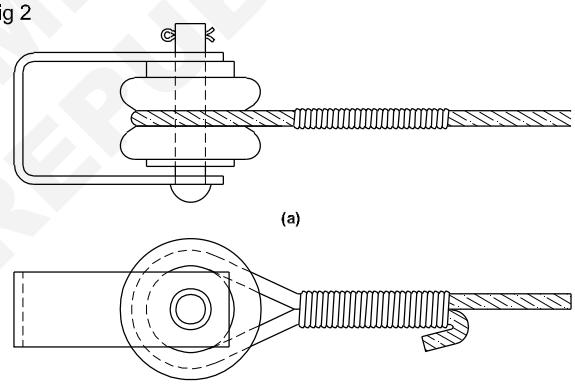
Fig 2



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TASK 3 : **Fasten Jumper in suspension type insulator**

1 Keep the ladder on the pole and ask the helper to hold the ladder. Climb up the ladder with the guide rope and spanner set.

2 Fix the suspension insulator to the cross-arm.

3 Ask the helper to properly lift the conductor to the cross-arm position.

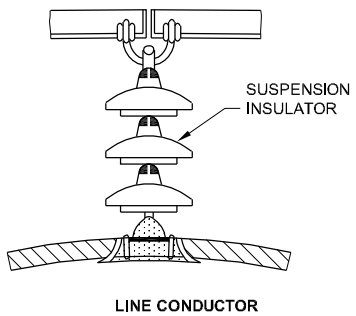
4 Place the conductor in between two clamps.

5 Tight the bolt & nut of the clamp perfectly.

6 Bind the ACSR conductor with 14 SWG aluminium wire tightly Fig 1 in the suspension insulator.

7 Complete the work and report to your instructor.

Fig 1



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Perform installation of overhead domestic service lines

Objectives: At the end of this lesson you shall be able to
- **select the place to erect the pole**
- **select the type of pole to be erected**
- **fix the cross-arm on the pole**
- **dig the pit and erect the pole.**

Requirements

Tools/Instruments

- D.E. spanner set 6mm to 32mm - 1 Set.
- Combination pliers 200mm - 1 No.
- Heavy duty screwdriver 300mm - 1 No.
- Safety belt to work on pole - 1 No.
- Crowbar 2m long 40mm dia - 1 No.
- Spade - 1 No.
- Shovel - 1 No.
- Plumb bob with thread - 1 No.
- Cotton or jute rope 15m long - 1 No.
- Hammer ballpein 500g - 1 No.
- Safety belt - 1 No.
- Bamboo ladder - 1 No.
- Draw pulley - 1 No.
- Aligning rod - 1 No.
- Metal ram - 1 No.

Materials

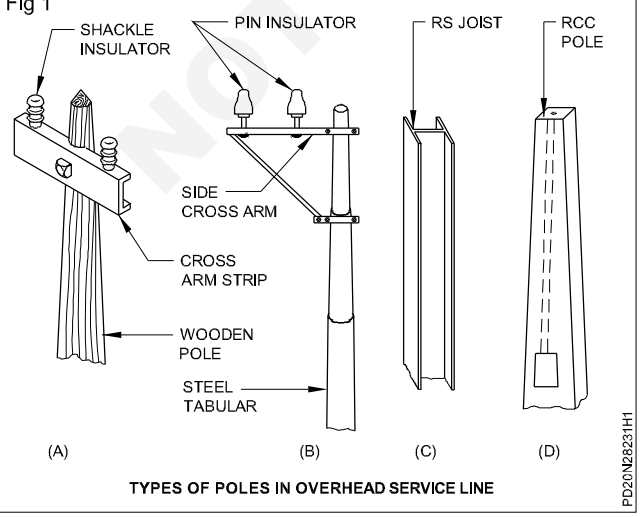
- Wooden/RCC/iron/tubular pole of 6m length - 1 No.
- Conductor ACSR rabbit/ weaset - as reqd.
- WP wire 1/1 8 TC (1.5 mm^2) - as reqd.
- M.S. angle iron cross-arm 50mm x 50mm x 6mm size suitable for 240V supply line - 1 No.
- 'C' clamp M.S. size as required with nuts, bolts and washers - 2 Sets.
- Country wood plank 2m long, 30cm width 5cm thick - 1 No.
- Cement, sand, blue metal chips etc as per the size of pit - as reqd.
- Stay insulator (egg insulator) - 2 Nos.
- Double screw stay tightener - 2 Nos.
- C.I. stay plate - 2 Nos.
- Stay rod - 2 Nos.
- H.D.G. steel wire (stay wire) 7/16 SWG - 16m
- 50 x 12mm size M.S. bolts and nuts with washers - 2 Nos.
- Base plate for pole - 1 No.
- Casuarina pole of suitable height - 4 Nos.
- Wooden box of suitable size having 2 side openings for concrete pedestal - 1 No.

PROCEDURE

1 Select the place for fixing the pole near the building based on the span.

2 Select the type of pole to be erected. (Fig 1)

Fig 1



TYPES OF POLES IN OVERHEAD SERVICE LINE

3 Dig a pit about 1/6th height of the pole having a diameter of minimum 3 times that of the dia of the pole bottom.

4 Prepare a mixture of concrete having a ratio 1:2:4 (one part cement, two part coarse sand and four part 2 cm blue metal chips) and pour the same in the bottom of the pit to a height of 15cms.

5 Ram the concrete and allow it to settle for a minimum period of 48 hours.

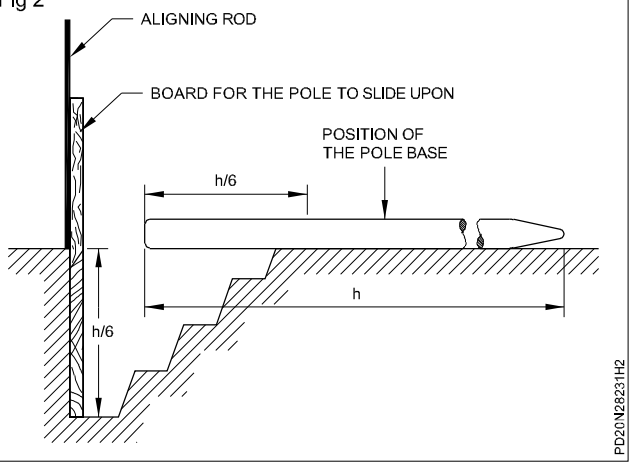
6 Keep the base plate for the pole at the bottom of the pit.

7 Fix a vertical straight pole on the plumb line in the pit. Refer (Fig 2)

8 Bring the pole and place it near the pit so that the bottom of the pole is at the edge of the pit.

9 Insert the wooden plank (board) vertically at one side of the pit facing opposite to the bottom portion of the pole.

Fig 2



10 Fix the cross arms at the top of the pole below 30 cm from the top, with the help of 'C' clamps rigidly.

11 Tie the two ropes just below the cross arms.

Ensure that the cross arm is in the required direction

12 Place the casuarina pole at a distance of 1/3 height of the top and also 1/3 height from the bottom of the pole.

13 Prepare concrete mixture in the ratio of 1:3:4 (cement, sand and 1 cm blue metal chips).

14 Lift the pole step by step with the help of a rope and casuarina pole (Fig 3) and place it on the pit exactly vertical.

15 Check the vertical position with the help of an aligning a rod and plumb bob.

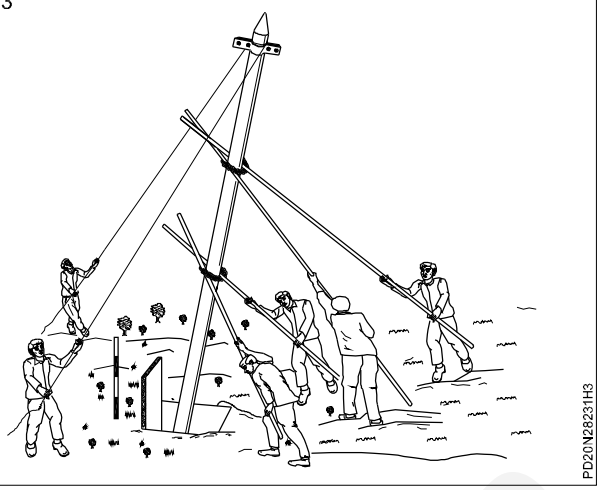
16 Pour the concrete mixture around the pole inside the pit and then place the wooden box around the pole.

17 Pour the concrete mixture in the box to a height of 0.5m above the ground level. Ram the mixture properly.

18 Cure the cement concrete for about 48 hours.

19 Remove the wooden box and plaster the cement concrete above the ground surface to have a smooth finish.

Fig 3



20 Fix the stay rod to the ground at a distance so as to get 45° to 60° between ground level and stay wire should be placed in the opposite direction to the line.

21 Cut the stay wire into 2 pieces of equal length.

22 Fix one end of each piece of the stay wire to the strain insulator (egg insulator).

23 Fix the other end of the second piece of stay wire to the stay. Tighten using a thimble.

24 Fix the stay and tighten to the stay.

Assuming the stay rod is fitted to the ground through a concrete structure which was sufficiently cured.

25 Tighten the stay tightener nut till there is no sag in the stay.

After drawing the overhead lines the stay should be tightened to compensate the tension of the overhead lines and to keep the pole in the vertical position.

26 After stringing the overhead lines, give service connection (using weather proof wire up to 35 m only) to proposed domestic consumer premises.

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Measure current carrying capacity of conductors

Objectives: At the end of this lesson you shall be able to
- **identify and select 3 different conductors i.e. copper, aluminium and alloy**
- **connect the circuit and measure the breaking current of the conductor.**

Requirements

Tools/Instruments/Equipment

- Trainees tool kit - 1 No.
- Ammeter M.C. 0-10A - 1 No.
- Voltmeter M.C. 0-15V - 1 No.
- Rheostat 270W 2A - 1 No.
- Lead acid battery 12V 60AH - 1 No.

Material

- Wooden board with switch 16A 250V - 1 No.
- 32 SWG copper conductor, aluminium conductor and alloy conductor - 10 cm
- Connecting wires 2.5 sq.mm copper - as reqd.

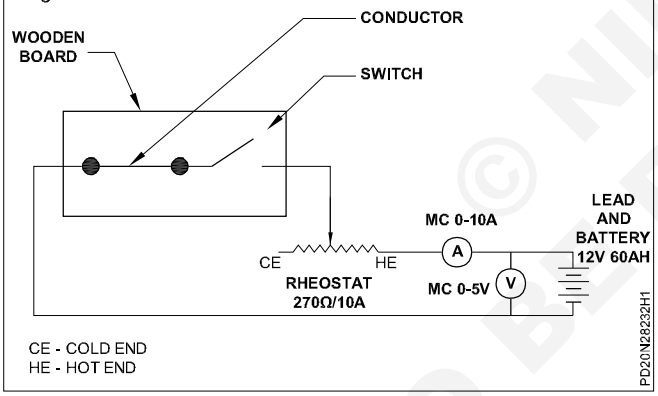
PROCEDURE

1 Select 32 SWG copper conductor, aluminium conductor and alloy conductor of 10 cm length each.

2 Connect it on the test board. (Fig 1)

3 Connect rheostat, ammeter voltmeter and battery.

Fig 1



4 Keep rheostat at cold end (maximum resistance position) and switch 'on' and note the ammeter and voltmeter readings and enter in the Table 1.

5 Move the rheostat at middle position and note down the ammeter and voltmeter readings and enter in Table 1.

At this stage the conductor may get heated up (or) it will show the system of heating.

6 Adjust further more the rheostat position to hot end (reduce the resistance) slowly keeping a watch on conductor it may brake now.

7 Observe if the conductor is not broken and increase further position of rheostat towards hot end till the conductor breaks and note down the corresponding meter readings in Table 1.

8 Note down this is the maximum current carry capacity of the conductor.

If the conductor is not broken, reduce the thickness of conductor (or) change the battery.

9 Connect the aluminium and alloy conductor separately and repeat the steps to find the maximum current capacity of the 2 to 9 conductors.

10 Tabulate all the readings and show to your instructor.

11

a Maximum current capacity of copper conductor is _____ Amp

b Maximum current capacity of aluminium conductor is _____Amp

c Maximum current capacity of alloy conductor is _____Amp

Sl.No.	Rheostat Position			Conductor	Voltage	Current	Remarks
	Cold end	Mid end	Hot end				
1		X	X	Copper			
2	X		X				
3	X	X					
4		X	X	Aluminium			
5	X		X				
6	X	X					
7		X	X	Alloy			
8	X		X				
9	X	X					

X' denotes the inactive positions of the rheostat and blank space denotes active positions in the above Table 1.

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Practice installation and sealing of energy meters

Objectives: At the end of this exercise, you shall be able to
- **practice making hole in, energy meter board fixing in wall**
- **mount the energy meter, cut out neutral link on the board**
- **connect energy meter, cut - out link as per IE rule**
- **fix the energy meter board on the wall**
- **sealing the meter.**

Requirements

Tools/Instruments

- Steel rule 300mm - 1 No.
- Insulated Side cutter 150mm - 1 No.
- Combination pliers 200mm - 1 No.
- Hand drilling machine with 3mm and 6mm drills - 1 No.
- Insulated Screwdriver 200mm with 4mm blade - 1 No.
- Insulated Connector screwdriver 100mm - 1 No.
- Poker 200mm long with 4mm dia. stem - 1 No.
- Electrician's knife DB 100 mm - 1 No.
- Firmer chisel 12mm wooden handle - 1 No.
- Ball peen hammer 500 gm. - 1 No.
- Tenon-saw 250mm - 1 No.
- Mallet with 7.5cm dia. head 500 gm - 1 No.
- Neon tester 500 V - 1 No.
- Scriber 200mm with 3mm dia. stem - 1 No.
- Mason's trowel - 1 No.
- Tray for cement mortar - 1 No.
- Electric drilling machine - 1 No.
- Mason bit 8mm - 1 No.
- Mason bit 20mm - 1 No.
- Crimping tool (10mm) - 1 No.

Equipment Machines

- Single phase energy meter 10/15A 250V

Materials

- PVC insulated copper cable 2.5 square mm - 3 m
- Tinned copper wire 14 SWG - 1 m
- Iron-clad cut out 16A - 1 No.
- Neutral link 16A - 1 No.
- T.W. board 250x250x40mm - 1 No.
- Porcelain spacers - 4 Nos.
- Teak wood gutties (wooden plugs) 40mm square x 60mm long x 30mm square - 4 Nos.
- Wood screws No.4 x 25 mm - 3 Nos.
- Cement - 1/2 kg.
- River sand - 2 kgs
- Rawl plug No.8 - 4 Nos
- Rawl plug Compound - 25 gms.
- Chalk piece (colour) - 1 No.
- Wood screws No. 50 x 8 mm - 4 Nos.
- Lead seal (or) polycarbonite seal - 3 Nos.
- Standard steel wire - 100 cm.

PROCEDURE

TASK 1 : **Preparation of wall for mounting meter board**

If the masonry wall is of a rigid type, follow this method.

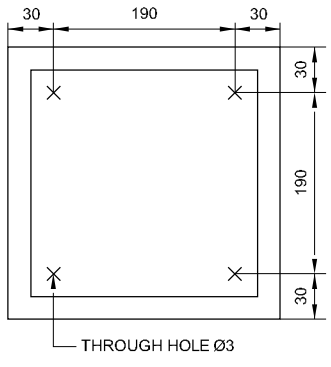
1 Drill four numbers of through holes of 3mm dia. in the T.W. board as shown in Fig 1.

2 After ascertaining the height of the meter board position with respect to the ground, keep the T.W. board on the wall and mark the position of the holes of the board on the wall with a scriber.

Take care to keep the board in a correct horizontal/vertical position on the wall.

3 Make drill 40mm depth using electric drilling mason bit 8mm.

Fig 1



REAR SIDE LAYOUT OF THE METER BOARD

This will enable the broken pieces of mortar to come out without gripping the rawl bit. Otherwise the bit will not come out easily at the end of the operation or the bit may even break.

4 Repeat this method in the other three markings.

5 Dip the rawl plugs in water, plug them in the holes and slightly hammer on them to make them flush with the wall.

You may use rawl powder compound (asbestos based) in the place of rawl plugs. In this case the powder needs to be mixed with water to make a semi-solid paste before filling it into the holes tightly.

TASK 2: **Preparation of wall for drawing the service connection**

Sometimes the service connection wires need to be taken through the wall using a G.I. pipe. There is then the necessity of making a hole through the wall with the help of a pipe jumper. The method to do it is as explained below. The diameter of the pipe jumper depends on the diameter of the service connection pipe and the length of the pipe jumper depends upon the wall thickness.

1 Fit 20mm mason bit in electric drilling machine.

2 Inspect the wall and mark a place on the wall considering the nearest point to the electric service pole.

3 Make connection electric drilling machine and drill on the wall.

The marking should be close to the meter terminals. It should not be on the R.C. . beam or granite stone embedded in the wall.

In the case of an old building check whether any concealed wiring is running through the wall at the place of marking. In such cases the marking should be done at a different place. However, in buildings, where wiring exists, switch `off' the mains, remove the fuse-carrier and keep it under your custody.

4 Clear the hole.

5 Insert the G.I. pipe for the service cable in the hole and plaster around the pipe with cement.

Wiring up a meter board and sealing

1 Confirm the capacity of the energy meter.

2 Select and confirm the size of the cable as per the meter rating.

Follow the standard colour code for phase and neutral.

3 Position the meter, I.C. cut-out and earth-plate as per layout (Fig 2) and mark their position as per layout on the T.W. board.

4 Mark the cable entry positions and mounting screw positions.

5 Select the drill bit according to the cable size.

6 Drill through holes in the T.W. board for cable entry and pilot holes for fixing the meter, I.C. cut out and the earth plate.

7 Fix the meter, I.C. cut out and the earth plate.

Fig 1

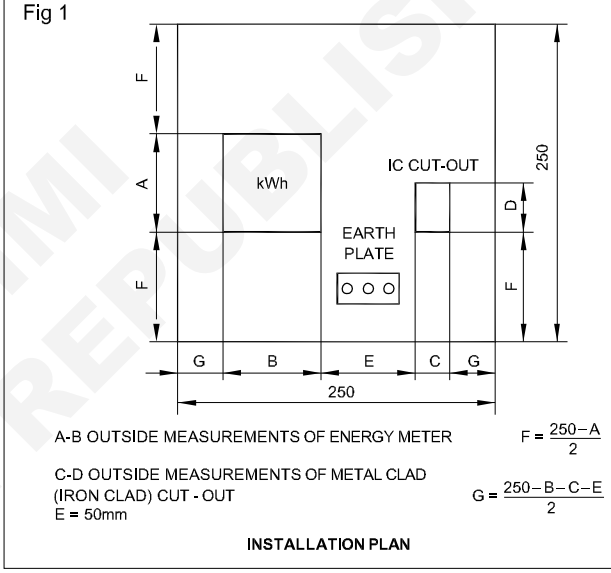
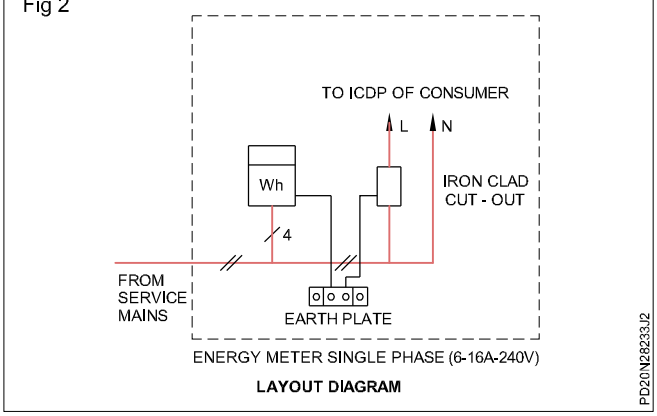


Fig 2

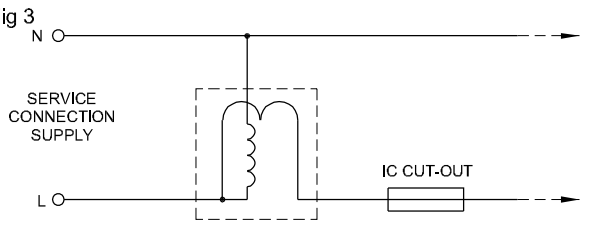


8 Determine the length of the cables according to the layout and cut them with reference to Figs 1 and 2.

9 Connect the supply leads and the outgoing phase wire to the I.C. cut–out. Pass the neutral directly as per the wiring diagram. (Figs 3 and 4)

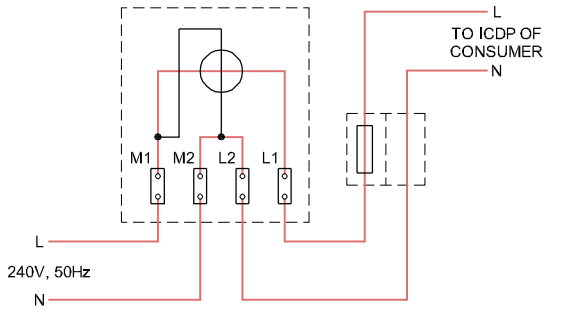
10 Earth the casing of the meter and the I.C. cut out body to the earth plate.

Fig 3



CIRCUIT DIAGRAM

Fig 4

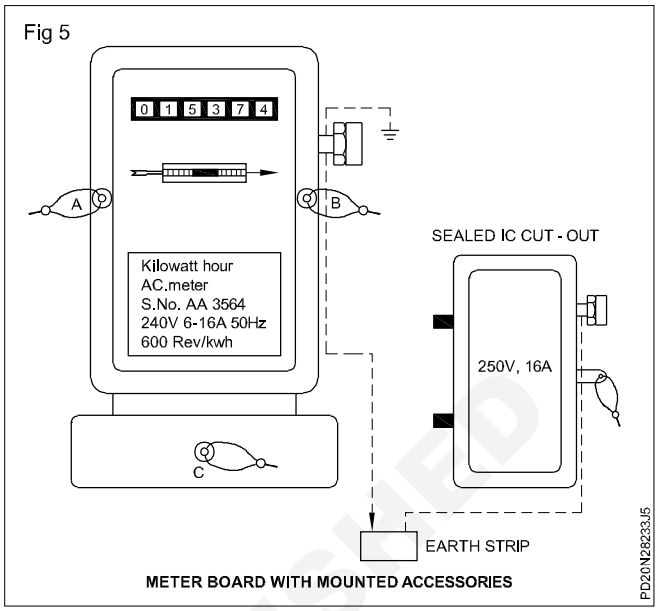


WIRING DIAGRAM

11 Mount the meter board on the aimed wall with the help of 45mm wood screws.

12 The completed work should look as shown in Fig 5.

Fig 5



METER BOARD WITH MOUNTED ACCESSORIES

TASK 3: **Energy meter sealing**

1 Check the dial cover pin hole on both side of energy meter and similarly check the terminal cover hole.

Ensure all three holes are in straight line.

2 Insert the steel wire into the pin hole and draw the wire from other end.

3 Make the twist and insert the printed seal wire of the lead seal, entry hole and twist again.

4 Crimp the lead seal with crimping tool (or) poly carbonate seal

5 Repeat the step 1 and 2

6 Get the approval from the instructor.

Install bus-bar and bus coupler on LT line

Objectives: At the end of this exercise, you shall be able to
- **determine the location for installing bus bar and select the bus bar with bus coupler**
- **mount and fix the bus bar**
- **insert the plug -in-boxes in the bus bar system and also bus coupler**
- **test for earth continuity of bus bar and for insulation resistance.**

Requirements

Tools/Instruments

- Electrician tool kit - 1 No.
- DE spanner set (6 mm to 25 mm) - 1 Set
- Crimping tool - 1 Set
- Ladder with adjustable height - 1 No.
- High stool - 1 No.
- Hand hacksaw frame 300 mm - 1 No.
- Megger 500V - 1 No.

Materials

- Busbar of available current rating and standard length / current rating - 2 Nos.
- Plug - in boxes 32A - 2 Nos.
- Busbar brackets, M.S flat, for suspending the bus bar or GI pipe for supports and all supporting accessories - as reqd.
- Nut and bolts size and quantity for busbar extension standard accessories - as reqd.
- Bus coupler - 1 No.

PROCEDURE

1 Trace the workshop layout and calculate the total electrical capacity of machines, main power supply entry point and determine the rating.

2 Determine the busbar layout and the required length of the busbar.

3 Determine from the site what type of support is required to lay the busbar.

4 Mount and fix the busbars to the supporting structure. (Fig 1 and Fig 2).

5 Insert the plug - in-boxes in to the plug -in-points.

Fig 1

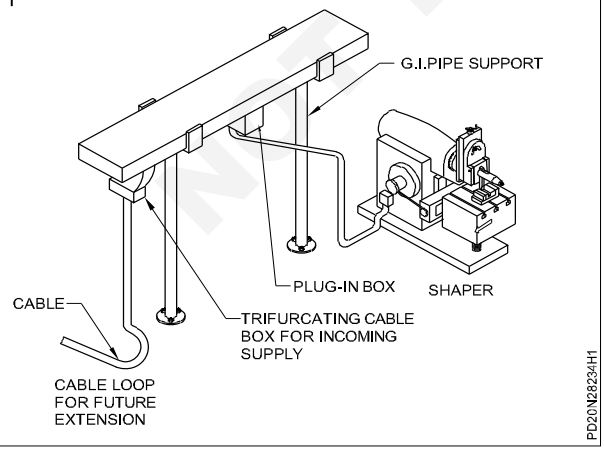
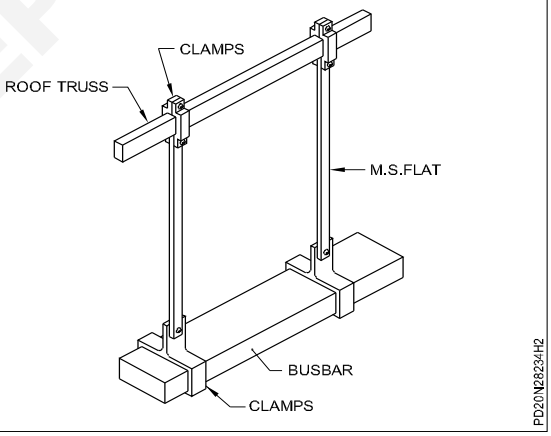
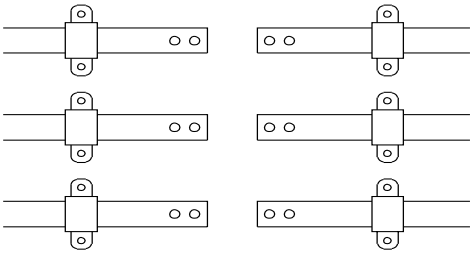


Fig 2



6 Couple the new busbar mechanically and electrically by using bus coupler, if another length is needed. (Fig 3)

Fig 3



If any over lapping ends of the busbar join by bolting together.

7 Secure busbar with screws locking plates.

A connector - assembly which is commercially available comprises of

- **rubber locating ring,**
- **busbar insulating tube**

If connector insulating tube in knocked out condition. While coupling, make sure that the connector - assembly is properly secured.

8 Terminate the plug in boxes to the loads through metal conduit runs and suitable cables.

9 Test the bus bar system for earth continuity.

10 Test the system for continuity and insulations.

Practice working with thermo version camera

Objectives: At the end of this exercise, you shall be able to
- **working with a thermal version camera.**

Requirements

Tools/Instruments

- Thermal vision camera
- Safety gear / PPE

PROCEDURE

1 Preparation

- Ensure the camera is in working order and fully charged or has adequate power.
- Check that the camera lens is clean and free from debris.
- Select the appropriate thermal imaging mode and settings for your application.

2 Safety precautions

- Identify potential safety hazards in your work area, such as electrical equipment or flammable materials.
- Maintain a safe distance from any potentially hazardous objects.
- Be aware of any potential electrical or fire risks and take precautions accordingly

3 Image capture

- Aim the camera at the object or area you want to inspect.
- Adjust focus and settings as needed to obtain a clear thermal image.
- Capture the thermal images or video recordings as required.

4 Interpretation

- Interpret the thermal images, looking for temperature variations or anomalies that may indicate issues or anomalies in the objects or areas being inspected.

5 Report Generation

- Create detailed reports of your findings, including images, temperature data, any observations or recommendations.

6 Safety and compliance

- Ensure that your work complies with local regulations and safety standards.
- Follow any specific safety guidelines provided by your organization or client.

7 Data strorage and analysis

- Store captured data securely and label it for easy reference.
- Analyze the thermal data over time to track changes and identify trends or issues.

8 Maintenance

- Regularly clean and maintain the thermal camera as per the manufacturer's instructions.
- Ensure that calibration is performed at the recommended intervals.

9 Training and continuous learning

- Stay updated with the least advancements in thermal imaging technology and techniques.
- Continue to enhance your skills through training and practice.

Remember that thermal imaging cameras are valuable tools for various applications, including building inspections, electrical troubleshooting, and industrial maintenance. However, proper training and adherence to safety protocols are essential to ensure accurate results and prevent accidents or damage to equipment. Always consult the user manual for your specific camera model and follow the manufacturer's recommendations.

Fig 1

Fig 2

Fig 3

Practice on the collecting meter reading of various meter

Objectives: At the end of this exercise, you shall be able to
- **collect and study the report of single phase 230 kw H meter**
- **collect and study the report of 3 phase 230 v, kw H meter.**

PROCEDURE

Meter reading taken by analogue meter

1 Stand directly in front of the meter.

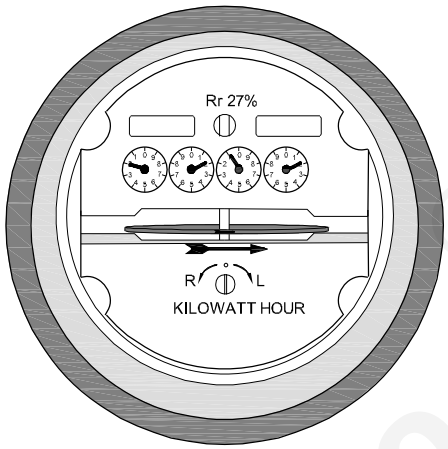
2 Read each dial in turn starting from left to right writing down each figure as you go.

3 When a dial hand points between numbers, record the lower number.

4 It is important to only read dials that are black.

5 In this example the reading would be 2-2-1-2 as (Fig 1)

Fig 1



Procedure for taking reading on Electromechanical/digital type meters

1 Write down the first 5 numbers shown from left to right.

2 Ignore the numbers after the decimal point, sometimes shown in red.

3 In this type the reading would be 9_9_9_9_5 as shown in (Fig 2)

Procedure for taking reading on TOD type meters

1 while taking reading on TOD meter more than one parameter reading should be take

2 the parameters are KW, KWh, KVA, KVarh lag or lead, PF etc

3 These are also taking by different times ie. off peak, peak and normal.

Fig 2

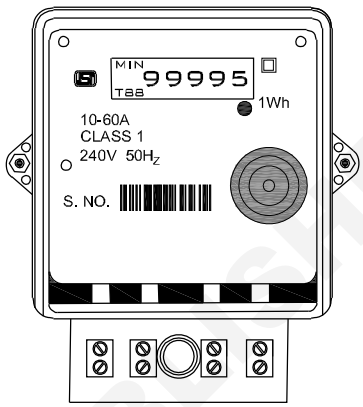
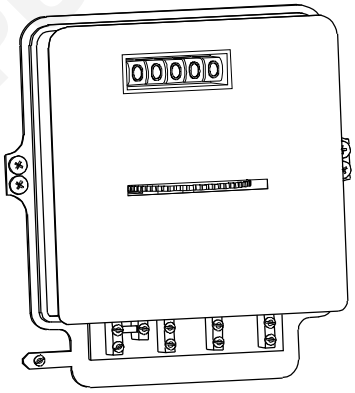


Fig 3



4 Most of energy meters, these are mentioned as KWh1, KWh2, KWh3 and KW/MD 1, MD2, MD3 and remaining parameters like as this model.

5 In this type the reading would be 00000 as shown in (Fig 3)

In some meters like Feeder meter/Boarder meter, Net meter(used in solar electric connection), Import and export reading should be take as Normal/TOD reading if needed. In this type of meter, readings will send via sim card in system /mobiles phones. In smart meters sims are inserted and all messages has been send time to time.

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Practice study of MRI reports

Objectives: At the end of this exercise, you shall be able to
- **collect and study the report of single phase 230 kw H meter**
- **collect and study the report of 3 phase 230 v, kw H meter.**

Requirements

Tools/Instruments

- MRI meter with connecting leads - 1 No.

PROCEDURE

TASK 1 : **Collect and study the report of single phase 230V, KWH meter**

1 Connect the MRI meter the optical part of single phase energy meter.

2 Switch on the MRI meter, all data in the energy motor send to MRI motor with in 5 minute.

3 Data are store in the memory of MRI meter.

4 Plug out the connecting probe of MRI meter.

5 To study the report, connect the MRI meter to the computer or by manually collect the data from MRI.

6 After 30 minutes' delay again connect the MRI to the energy meter and download the reading.

7 Compare the two data with the help of Table-1

8 Show it to your instructor and get approval.

Table 1

Data	MRI 1	MRI 2
Date		
Time		
RN		
YN		
BN		
LR		
LY		
LB		
Power factor		
Maximum power consumed interval of 30 minutes or KWH		
Cumulative power consumed in KWH		
Maximum demand in KVA internal of 30 minutes in KVAH		
Cumulative demand in KVAH		
Frequency in HZ		

TASK 2 : **Collect and study the report of 3 phase 230 v KWH meter 3 phase 230V KWH meter**

1 Repeat the step of 1 to 6 but connect the meter 3 phase 230V KWH meter.

2 Compare the two data with the help of Table-2

3 Show it to your instructor and get approved.

Table 2

Data	MRI Reading 1	MRI Reading 2
Date		
Time		
Voltage		
Current		
Power Construct Maximum interval 30 minutes in KWH		
Cumulative power in KWH		
Frequency in HZ		

Table 3

Data	MRI Reading 1	MRI Reading 2
Date		
Time		
Phase sequence		
R_N		
Y_N		
B_N		
L_R		
L_Y		
L_B		
Instant Power factor		
Instant power actual KW		
Instant power apparent KVA.		
Cumulative actual power in KWH		
Maximum power reached 30 minutes internal in KW		
Maximum power Apparent 30 minutes interval in KVA		
KVAH R_1 - 6.00 am to 9.00 am R_2 - 6.00 am to 9.00 pm R_3 -9.00 am to 10.00 pm R_4 -9.00 am to 6.00 pm R_5-10.00 am to 6.00 pm		
Cumulation Apparent power in KVAH.		
KWH R_1 - 6.00 am to 9.00 am R_2 - 6.00 am to 9.00 pm R_3 -9.00 am to 10.00 pm R_4 -9.00 am to 6.00 pm R_5-10.00 am to 6.00 pm		
AVG power factor.		
Relative power KVA_{rh} Lag		
Relative power KVA_{rh} Lead		
Frequency in HZ		
MD Riser count		
Power ON/OFF status		

Take meter reading by USB/optional cable

Objectives: At the end of this exercise, you shall be able to
- **take meter readings using a USB or optical cable.**

Requirements			
Tools/Instruments			
• Computer system	-1No.	• Meter • USB/optional	-1No. -as reqd.

PROCEDURE

1 **Connect the Cable:** Plug one end of the USB or optical cable into the meters interface port and the other end into the corresponding port on your computer.

2 **Install Software:** If you haven't already, install the meter reading software on your computer. Follow the installation instructions provided with the software.

3 **Driver Installation:** If your cable requires divers, make sure they are properly installed on your computer.

4 **Turn on the Meter:** Power on the meter and ensure it's in the correct mode for data communication

5 **Launch Software:** Start the meter reading software on your computer

6 **Configure Settings:** Configure the software settings to match the specifications of your meter This might include selecting the communication port, baud rate and other relevant parameters

7 **Initials Reading:** Use the software's interface to initiate the reading process. This may involve clicking a "Read or similar button

8 **Data Retrieval:** The software should communicate with the meter through the USB or optical cable and retrieve the meter readings. The readings should be displayed on your computer screen

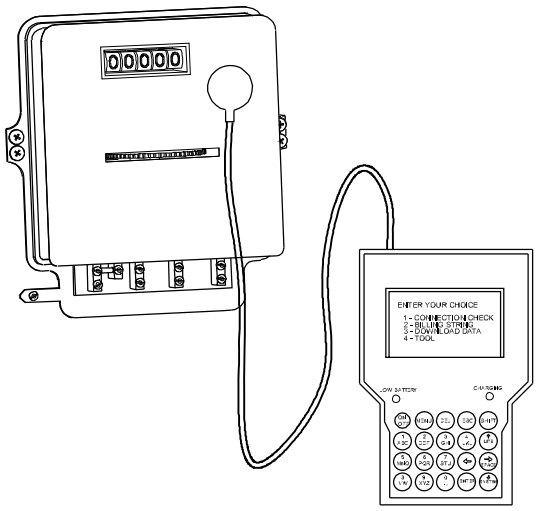
9 **Save Data :** Save the meter readings to a file or database for future reference

10 **Review and Analyze:** Review the data as needed for your specific application, such as billing or““monitoring.

11 **Disconnect:** Safely disconnect the USB or optical cable from both the meter and your computer

12 **Power Down:** Turn off the meter and close the meter reading software.““Please note that the exact steps and software interface may vary depending on the manufacturer and model of your meter and cable. Always refer to the user manual and documentation provided with your equipment for precise instructions. Additionally, ensure that you have the necessary permissions and access to use the meter and its data for your intended purpose.

Fig 1



Observe study log sheet at substation

Objectives: At the end of this exercise, you shall be able to

- **observing and studying log sheets at a substation is essential for monitoring and maintaining electrical systems.**

Requirements

Tools/Instruments

- Log Sheet

PROCEDURE

1 **Check the Date and Time :** Verify that the log sheet is up-to-date and reflects the time period you are interested in studying.

2 **Review Header Information:** Look for essential information at the top of the log sheet, including the substation's name, location, and identification numbers. Ensure it matches the substation you are inspecting.

3 **Examine Event Logs:** Study the log entries for various events and parameters. These may include voltage readings, current measurements, breaker operations, alarms, and maintenance activities. Pay attention to any abnormalities or irregularities.

4 **Record Keeping:** If required, make your own notes or records of the information you find. This can be useful for further analysis or reporting.

5 **Analyze Trends:** Identify trends or patterns in the data. Are there recurring issues or fluctuations in voltage/ current? Look for any indications of potential problems or maintenance needs.

6 **Cross-Check with Equipment:** If you have access, physically inspect the substation's equipment to verify that it matches the log entries. This helps ensure the accuracy of the records.

7 **Report Anomalies:** If you notice any anomalies, discrepancies, or signs of equipment failure, report them to the appropriate personnel immediately. Safety and maintenance concerns should be addressed promptly.

8 **Follow Procedures:** Adhere to established procedures and protocols for handling any issues or maintenance tasks that may arise during your observation.

9 **Document Findings:** After your observation, document your findings, including any corrective““actions taken or recommendations for future maintenance

10 **Compliance:** Ensure that all observations and actions taken comply with relevant safety standards and regulations

Remember that working in a substation can be hazardous, so prioritize safety at all times. If you are not qualified or trained to perform these tasks, consult with experienced personnel or supervisors for guidance and assistance.

Name & Signature			
	SHIFT I	SHIFT II	SHIFT III
OPERATOR			
SHIFT ASSISTANT			

DAILY LOG SHEET

		I	II	III			I	II	III
Trip Circuit of Bays	220kV Feeders	OK/NOT OK	OK/NOT OK	OK/NOT OK	Wkg Limits	Gas Pr.of CBs	OK/NOT OK	OK/NOT OK	OK/NOT OK
	110kV Feeders	OK/NOT OK	OK/NOT OK	OK/NOT OK		Temp Rise of Tfrs	OK/NOT OK	OK/NOT OK	OK/NOT OK
	11kV Feeders	OK/NOT OK	OK/NOT OK	OK/NOT OK		Leakage Current of Las	OK/NOT OK	OK/NOT OK	OK/NOT OK
	100 MVA Tfrs	OK/NOT OK	OK/NOT OK	OK/NOT OK	Spring Chg	220kV CBs	OK/NOT OK	OK/NOT OK	OK/NOT OK
	12.5 MVA Tfrs	OK/NOT OK	OK/NOT OK	OK/NOT OK		110kV CBs	OK/NOT OK	OK/NOT OK	OK/NOT OK
DC System	Battery I &II	OK/NOT OK	OK/NOT OK	OK/NOT OK		11kV CBs	OK/NOT OK	OK/NOT OK	OK/NOT OK
	Charger I & II	OK/NOT OK	OK/NOT OK	OK/NOT OK	Availability	Fire Fighting Eqpts	Yes/No	Yes/No	Yes/No
	Earth Leakage	NIL/YES	NIL/YES	NIL/YES		Esntl Tools/ Multimter	Yes/No	Yes/No	Yes/No
Annunciation/Indication	220kV Feeders	OK/NOT OK	OK/NOT OK	OK/NOT OK		Earthing Rods	Yes/No	Yes/No	Yes/No
	110kV Feeders	OK/NOT OK	OK/NOT OK	OK/NOT OK		Gloves/Raincoats/FA kit	Yes/No	Yes/No	Yes/No
	11kV Feeders	OK/NOT OK	OK/NOT OK	OK/NOT OK		Key of Panel/Kiosks	Yes/No	Yes/No	Yes/No
	100 MVA Tfrs	OK/NOT OK	OK/NOT OK	OK/NOT OK	Wkg Condition	BSNL Telephone	OK/NOT OK	OK/NOT OK	OK/NOT OK
	12.5 MVA Tfrs	OK/NOT OK	OK/NOT OK	OK/NOT OK		FCT	OK/NOT OK	OK/NOT OK	OK/NOT OK
	OLTC-RTCC	OK/NOT OK	OK/NOT OK	OK/NOT OK		Carrier	OK/NOT OK	OK/NOT OK	OK/NOT OK
Remote Operation	220kV CBs	OK/NOT OK	OK/NOT OK	OK/NOT OK		DC Emergency Light/Tourch	OK/NOT OK	OK/NOT OK	OK/NOT OK
	110kV CBs	OK/NOT OK	OK/NOT OK	OK/NOT OK	Weather	Rain	Yes/No	Yes/No	Yes/No
	OLTC 100MVA Tfr1	OK/NOT OK	OK/NOT OK	OK/NOT OK		Lightning	Yes/No	Yes/No	Yes/No
	OLTC 100MVA Tfr2	OK/NOT OK	OK/NOT OK	OK/NOT OK		Storm	Yes/No	Yes/No	Yes/No
	OLTC 12.5MVA Tfr1	OK/NOT OK	OK/NOT OK	OK/NOT OK		Normal	Yes/No	Yes/No	Yes/No
	OLTC 12.5MVA Tfr2	OK/NOT OK	OK/NOT OK	OK/NOT OK	Patrolling of Yard		Yes/No	Yes/No	Yes/No

Remarks:

Verified the above entries. Following Remedical action taken/Rectification done by AE (Mtce)

Time	Battery Chargers											
	Battery Charger 1				Battery Charger 2				Comm Battery 1		Comm Battery 2	
	V	I Load	I Chg	I Bat	V	I Load	I Chg	I Bat	V (DC)	I (DC)	V (DC)	I (DC)
0:00												
1:00												
2:00												
3:00												
4:00												
5:00												
6:00												
7:00												
8:00												
9:00												
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17:00												
18:00												
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20:00												
21:00												
22:00												
23:00												
24:00												

Battery Voltage							
Plante Bat 1		Plante Bat 2		Comm Bat 1		Comm Bat 2	
Cell NO	V	Cell NO	V	Cell NO	V	Cell NO	V
P-N		P-N		P-N		P-N	
P-E		P-E					
N-E		N-E					
Remarks :							

Time	220KV FEEDER							220KV FEEDER						
	KANHIRODE							ARECODE						
	VOLTAGE	CURRENT	MW	MVAR	MWH		CONS	CURRENT	MW	MVAR	MWH		CONS	F (HZ)
	V	I			IMP	EXP		I			IMP	EXP		
0:00														
1:00														
2:00														
3:00														
4:00														
5:00														
5:30														
6:00														
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22:00														
23:00														
24:00														

Time	100MVA TFR 1 (220 KV SIDE)					100MVA TFR 2 (220 KV SIDE)					12.5 MVA TFR 1 (110 KV SIDE)					12.5 MVA TFR 2(110 KV SIDE)				
	I	MW	MVAR	MWH	CONS	I	MW	MVAR	MWH	CONS	I	MW	MVAR	MWH	CONS	I	MW	MVAR	MWH	CONS
0:00																				
1:00																				
2:00																				
3:00																				
4:00																				
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5:30																				
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24:00																				

Time	110KV FEEDER PANOOR							110KV FEEDER PINARAYI					
	VOLTAGE	CURRENT	MW	MVAR	MWH		CONS	CURRENT	MW	MVAR	MWH		CONS
	V	I			IMP	EXP		I			IMP	EXP	
0:00													
1:00													
2:00													
3:00													
4:00													
5:00													
5:30													
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21:30													
22:00													
23:00													
24:00													

Time	110KV FEEDER VADAKARA							110KV FEEDER MEPPAYYUR					
	VOLTAGE	CURRENT	MW	MVAR	MWH		CONS	CURRENT	MW	MVAR	MWH		CONS
	V	I			IMP	EXP		I			IMP	EXP	
0:00													
1:00													
2:00													
3:00													
4:00													
5:00													
5:30													
6:00													
6:30													
7:00													
7:30													
8:00													
9:00													
10:00													
11:00													
12:00													
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15:00													
16:00													
17:00													
18:00													
18:30													
19:00													
19:30													
20:00													
20:30													
21:00													
21:30													
22:00													
23:00													
24:00													

TIME	Transformer Tap Position & Temparature															
	100 MVA TFR 1				100 MVA TFR 2				12.5 MVA TFR 1				12.5 MVA TFR 2			
	Tap	OT	WT HV	WT LV	Tap	OT	WT HV	WT LV	Tap	OT	WT HV	WT LV	Tap	OT	WT HV	WT LV
0:00																
1:00																
2:00																
3:00																
4:00																
5:00																
6:00																
7:00																
8:00																
9:00																
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17:00																
18:00																
19:00																
20:00																
21:00																
22:00																
23:00																
24:00																

MW & MVAR REGISTER

TIME	110/11KV TF.1		110/11KV TF.2		TIME	110/11KV TF.1		110/11KV TF.2		TIME	110/11KV TF.1		110/11KV TF.2		TIME	110/11KV TF.1		110/11KV TF.2	
	MW	MVAR	MW	MVAR		MW	MVAR	MW	MVAR		MW	MVAR	MW	MVAR		MW	MVAR	MW	MVAR
00:00																			
00:15					06:15					12:15					18:15				
00:30					06:30					12:30					18:30				
00:45					06:45					12:45					18:45				
01:00					07:00					13:00					19:00				
01:15					07:15					13:15					19:15				
01:30					07:30					13:30					19:30				
01:45					07:45					13:45					19:45				
02:00					08:00					14:00					20:00				
02:15					08:15					14:15					20:15				
02:30					08:30					14:30					20:30				
02:45					08:45					14:45					20:45				
03:00					09:00					15:00					21:00				
03:15					09:15					15:15					21:15				
03:30					09:30					15:30					21:30				
03:45					09:45					15:45					21:45				
04:00					10:00					16:00					22:00				
04:15					10:15					16:15					22:15				
04:30					10:30					16:30					22:30				
04:45					10:45					16:45					22:45				
05:00					11:00					17:00					23:00				
05:15					11:15					17:15					23:15				
05:30					11:30					17:30					23:30				
05:45					11:45					17:45					23:45				
06:00					12:00					18:00					00:00				

Practice generation of electricity bill using SBM

Objectives: At the end of this exercise, you shall be able to
- **practice generation of electricity bill using SBM.**

Requirements

Tools/Instruments

• Computer system	-1No.	• SBM	-1No.
		• Thermal Scrall paper	-1No.

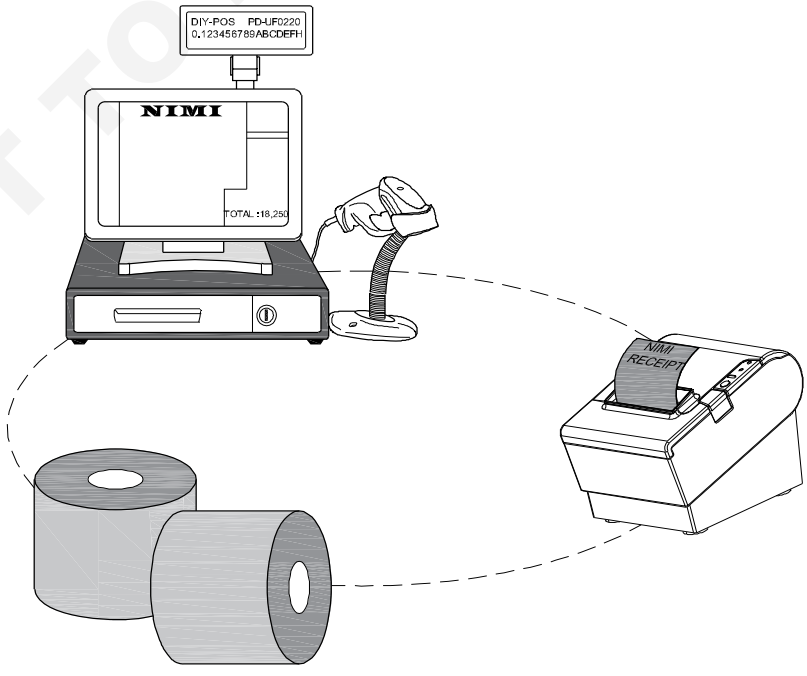
PROCEDURE

1 First energise the SBM Thermal Scroll paper
2 Feed thermal roll paper
3 Connect the SBM in computer using USB.
4 Download the previous reading data in computer and upload readings
5 In SBM menu select 'download' option and download previous reading data in SBM
6 Select Areacode/Daycode, then bill preparation.
7 While prepare billing, first collect the required data from meter
8 Enter the data in SBM accurately
9 The SBM generate bill.
10 Monitor the bill amount, verify the bill and confirm it is correct.
11 Then print bill and supply to consumer
12 Repeat the process from item No 7 to item No. 11 and complete the day code
13 After complete the day code work connect to computer and upload the data
14 The uploaded data send to centralized server The data will approved and Send message to consumer through email and registered mobile number.

Remember that

The rates can vary based on factors like usage of tiers, time of day and special tariff Determine the billing period as monthly, monthly or another predetermined period. Include additional charge such as taxes, surcharge or service fees. Deduct discounts or rebates that the consumer may be eligible The bill should include detailed information about the customer's consumption, rales and charge.

Fig 1



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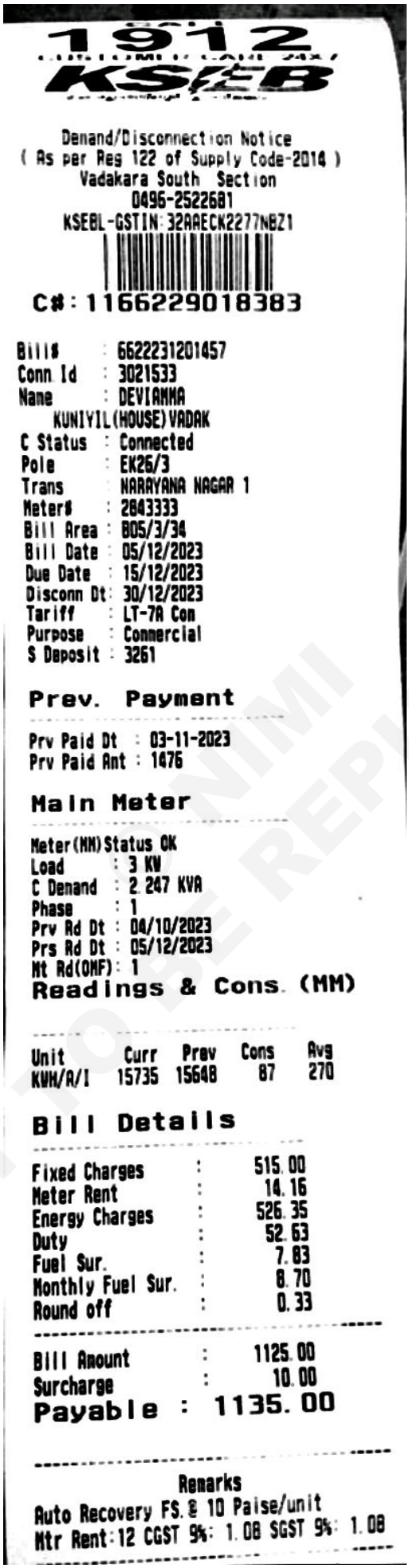


1912

KSEB

Demand/Disconnection Notice
(As per Reg 122 of Supply Code-2014)
Vadakara South Section
0496-2522681
KSEBL-GSTIN:32AAECK2277NBZ1

C#: 1166229018383

Bill# : 6622231201457
Conn Id : 3021533
Name : DEVIAMMA
KUNIYIL(HOUSE)VADAK
C Status : Connected
Pole : EK26/3
Trans : NARAYANA NAGAR 1
Meter# : 2843333
Bill Area : B05/3/34
Bill Date : 05/12/2023
Due Date : 15/12/2023
Disconn Dt: 30/12/2023
Tariff : LT-7A Con
Purpose : Commercial
S Deposit : 3261

Prev. Payment

Prv Paid Dt : 03-11-2023
Prv Paid Amt : 1476

Main Meter

Meter(MM) Status OK
Load : 3 KW
C Demand : 2.247 KVA
Phase : 1
Prv Rd Dt : 04/10/2023
Prs Rd Dt : 05/12/2023
Mt Rd(OMF): 1

Readings & Cons. (MM)

Unit	Curr	Prev	Cons	Avg
KWH/A/I	15735	15648	87	270

Bill Details

Fixed Charges	:	515.00
Meter Rent	:	14.16
Energy Charges	:	526.35
Duty	:	52.63
Fuel Sur.	:	7.83
Monthly Fuel Sur.	:	8.70
Round off	:	0.33
Bill Amount	:	1125.00
Surcharge	:	10.00

Payable : 1135.00

Remarks
Auto Recovery FS.@ 10 Paise/unit
Mtr Rent:12 CGST 9%: 1.08 SGST 9%: 1.08

Demonstrate shut down and work permit performance

Objectives: At the end of this exercise, you shall be able to
- **to demonstrate a shutdown and work permit procedure.**

Requirements	
Tools/Instruments	
• Shut down performance	• Work permit performance

PROCEDURE

1 Planning: Define the scope of the shutdown and work to be performed. Identify all potential hazards and develop a comprehensive plan.

2 Permit Issuance Obtain the necessary permits, such as a work permit, confined space permit, hot work permit, etc., depending on the nature of the task.

3 Safety Briefing Conduct a safety briefing for all personnel involved Emphasize the importance of adhering to safety procedures and using PPE.

4 Isolation and Lockout-Tagout." Isolate the equipment or area to be worked on, implement lockout- tagout procedures to prevent accidental startup.

5 Equipment Preparation: Ensure that all tools and equipment needed for the job are in good working order and meet safety standards.

6 Work Execution: Carry out the planned work while following established safety procedures. Monitor progress and address any issues promptly

7 Inspection and Testing: After the work is completed, inspect and test the equipment or area to ensure it is safe and ready for operation,

8 Permit Closure: Close out the work permit by verifying that all work has been completed, safety measures are in place, and it is safe to resume normal operations.

9 Documentation: Maintain detailed records of the entire process, including permits, inspections and any incidents or deviations from the plan.

10 Review and Continuous Improvement: After the shutdown and work permit procedure is completed, conduct a review to identify areas for improvement. Update procedures as needed.

Remember that the specific requirements and steps may vary depending on the industry and the nature of the work being performed. It's essential to involve safety experts and compliance officers to ensure that your procedure meets all necessary standards and regulations.

Permit to work on Electrical Equipment

I hereby declare that the following electrical equipment line is dead and isolated from all live conductors.

A Caution notice has been affixed to the controlling switches.

Here state exactly the Electrical Equipment/ Line on which it is safe to work.

Here state exactly the points at which the Equipment/ Line is isolated from all live parts and controlling

switch key numbers there of which are kept open

Sl. No	PARTICULARS	KEY NO
1 2 3 4 5		

Here state exactly at what points the Electrical Equipment/ Line is connnected to earth. If not earthed say so.

Here state exactly whether any of the person has prior line clear on the same equipment or line and if so, give details.

1 Signature with date, time and designation (when permit is by phone the name of the authorised person at opposite and must be noted)

2 Signature with date, time and designation (when permit is by phone the name of the authorised person at opposite end must be noted)

Note

1 This card after being signed by an authorised person, for the work to proceed, is to be handed to the person incharge of the work and retained by that person until the work is completed or stopped by the authorised person.

2 The Electrical equipment mentioned here in must not again made alive until the card has been signed and retumed by the person Incharge of the work to an authorised person. I hereby declare that all men, earthings and materials under my charge have cleared the sald Equipment/ Line and men have been wamed that it is no longer safe to work on the electrical specified on this card.

Practice isolation procedure and switching procedure preparation

Objectives: At the end of this exercise you shall be able to
- **carryout isolation procedure**
- **carryout switching procedure.**

Requirements

Tools/Instruments		Materials/Components	
• Safety gloves	- 2Nos.	• Earth Rods	- 3 Nos.
• Safety helmet	- 1No.	• With earthing clips	
• Safety shoe	- 1No.	• Lock with key & tags	- as reqd.

Notes : Instructer may take trainees to the nearest substation to show them isolation proceduce and switching proceduce preparation.

PROCEDURE

TASK 1:

1 Preparation:

a Conduct a thorough assessment of the work area, identifying all electrical equipment and potential hazards.

b Review relevant documentation to understand the electrical system and identify the equipment to be isolated or switched.

c Assemble all necessary tools and PPE.

d Inform all affected personnel about the work to be performed and establish communication protocols.

2 Isolation Procedure:

a Identify the specific electrical equipment or circuit to be isolated.

b Follow LOTO procedures to de-energize and lock out the equipment.

c Verify that all sources of electrical energy have been isolated and confirmed as de-energized using appropriate testing equipment.

d Attach lockout/tagout devices to control points and disconnect switches.

3 Switching Procedure:

a Plan the sequence of switching operations, considering safety and the desired outcome.

b Follow established protocols for switching operations, adhering to the one-step, one-operation rule.

c Use insulated tools and follow safety precautions when manipulating switches or circuit breakers.

d Continuously monitor the status of the equipment during switching to ensure safe and correct operation.

e Document each step of the switching procedure.

4 Verification:

a After completing isolation and switching, use testing equipment to verify that the equipment is de-energized and safe to work on.

Fig 1

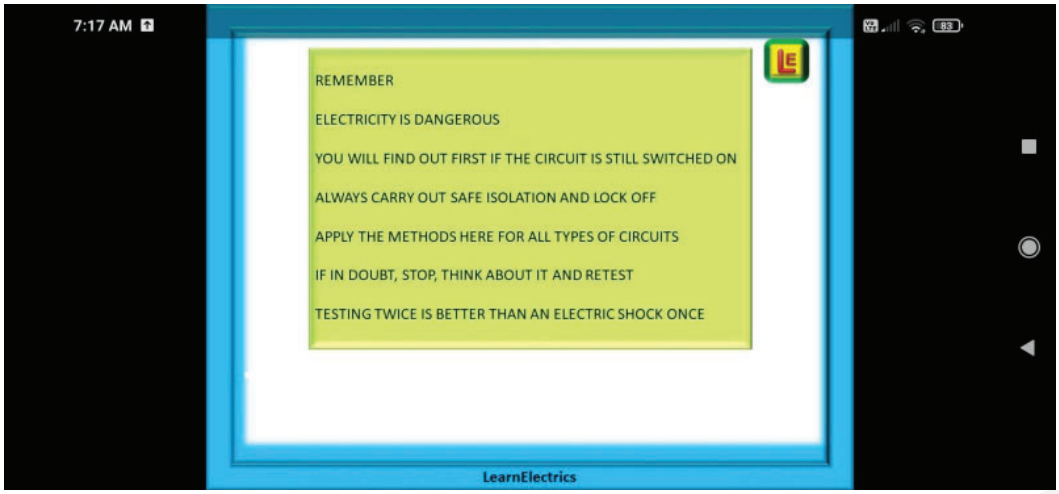
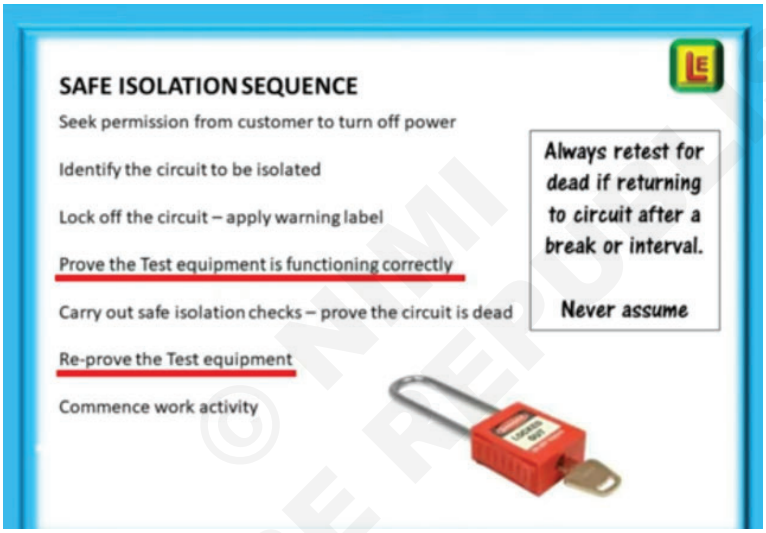


Fig 2



Practice implementation of permit system and LOTO system

Objectives: At the end of this exercise you shall be able to
- **practice permit system**
- **practice LOTO system.**

Requirements

Tools/Instruments
- PPE kit - 1No.
- Safety gloves - 2Nos.
- Safety helmet - 1No.

Materials/Components
- Lock/tags - as reqd.

Instructor may take trainees to the nearest substation and show them implementation of permit system and LOTO system

Notes : Implementing a Permit to Work (PTW) system and Lockout/Tagout (LOTO) system in a workplace is essential for safety. Here are the requirements and procedural steps for their practice implementation:

PROCEDURE

TASK 1:

1 **Request:** Employees request a PTW for work involving hazards.

2 **Review:** A designated person reviews the request and assesses hazards.

3 **Permit Issuance:** If deemed safe, issue a PTW specifying conditions.

4 **Work Execution:** The authorized person performs the work following the PTW.

5 **Monitoring:** Monitor work to ensure safety conditions are met.

6 **Completion:** Once work is complete, return the PTW and release the isolation.

7 **Closeout:** Review the job and document any lessons learned.

Requirements for Lockout/Tagout (LOTO) System:

1 **Written Program:** Develop a written LOTO program.

2 **Equipment Identification:** Identify and label all energy sources.

3 **Lockout Devices:** Provide lockout devices (locks, tags, etc.).

4 **Training:** Train employees on LOTO procedures and usage of devices.

5 **Procedure Development:** Create detailed LOTO procedures for each piece of equipment.

6 **Communication:** Ensure clear communication among employees about LOTO.

Procedural Steps for LOTO System:

1 **Preparation:** Identify equipment, energy sources, and isolate them.

2 **Notification:** Notify affected employees about the lockout.

3 **Lockout:** Apply lockout devices to energy sources.

4 **Verification:** Verify that all energy sources are locked and equipment is safe.

5 **Work Execution:** Perform the maintenance or servicing.

6 **Restoration:** After work is complete, remove lockout devices.

7 **Testing:** Test equipment to ensure it functions safely.

8 **Documentation:** Maintain records of LOTO procedures and activities.

9 **Training:** Periodically retrain employees and update procedures.

Remember that these systems require strict adherence to procedures and continuous training to ensure the safety of employees and the workplace. Always consult relevant safety regulations and involve safety experts when implementing PTW and LOTO systems.

Fig 1

Locks and danger tags

Every person working on isolated equipment should fit their own lock and/or danger tag. Alternatively, another management approved system that achieves an equivalent level of safety may be used.

When using locks or danger tags, consider the following:

Tags should be dated and signed

- Locks should be accompanied by a corresponding tag to identify who has locked out the plant
- Tags and locks should only be removed by the person who applied them or by the supervisor after consultation with the signatory of the danger tag.
- In the event that the person who applied the danger tag is unavailable, their tag or lock may only be removed in accordance with a management approved procedure
- Danger Tags and/or locks should be fitted to all isolation points.

Permit to work on Electrical Equipment

I hereby declare that the following electrical equipment line is dead and isolated from all live conductors.

A Caution notice has been affixed to the controlling switches.

Here state exactly the Electrical Equipment/ Line on which it is safe to work.

Here state exactly the points at which the Equipment/ Line is isolated from all live parts and controlling switch key numbers there of which are kept open.

Fig 2

Sl. No	PARTICULARS	KEY NO
1 2 3 4 5		

Here state exactly at what points the Electrical Equipment/ Line is connnected to earth. If not earthed say so.

Here state exactly whether any of the person has prior line clear on the same equipment or line and if so, give details.

1 Signature with date, time and designation (when permit is by phone the name of the authorised person at opposite and must be noted)

2 Signature with date, time and designation (when permit is by phone the name of the authorised person at opposite end must be noted)

Note:

1 This card after being signed by an authorised person, for the work to proceed, is to be handed to the person incharge of the work and retained by that person until the work is completed or stopped by the authorised person.

2 The Electrical equipment mentioned here in must not again made alive until the card has been signed and retumed by the person Incharge of the work to an authorised person. I hereby declare that all men, earthings and materials under my charge have cleared the sald Equipment/ Line and men have been wamed that it is no longer safe to work on the electrical specified on this card.

Identify various fuse sets viz , HRC , DO, 33KV fuse set, etc

Objectives: At the end of this exercise you shall be able to
- **identify various fuse sets**

Requirements

Tools/Instruments

- PPE kit
- Electrician tool kit

Materials/Components

- A4 paper - 2 Nos.
- Pencil (HB) - 1No.
- Scale - 1No.
- Rubber - 1No.

PROCEDURE

Identify and record specifications and other details of HRC, DO and 33kv fuse sets.

Fig 1

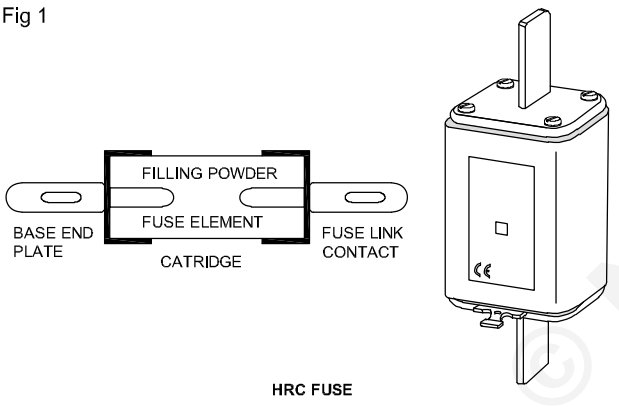


Fig 2

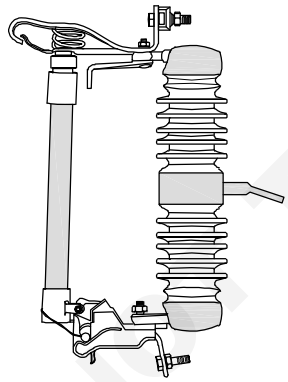
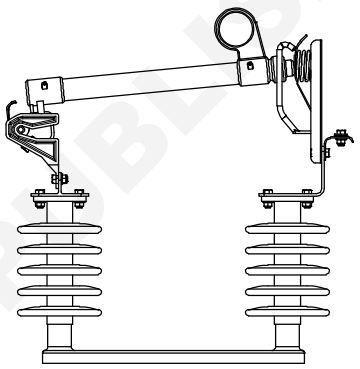


Fig 3



Instructor may take trainees to industry and explain the function of these fuses and record specification of each fuse.

1 **HRC fuses:** The majority of HRC fuses are built for use in industrial purposes where cables and machinery requires protection at high voltages and amperes.

2 **Drop out fuse**: The Dropout fuses are installed on the source side of the transformer.

— — — — —

Measure and select size of fuse wire

Objectives: At the end of this exercise you shall be able to
- **measure and select size of fuse wire.**

Requirements	
Tools/Instruments	**Materials/Components**
• standard wire gauge	• fuse rating chart

PROCEDURE

TASK 1:

1 Calculate the Maximum Current: Determine the maximum current that the circuit will carry under normal operating conditions. This can be done by analyzing the load and equipment specifications.

2 Consider Inrush Current: If the circuit experiences inrush currents when equipment is powered on, factor this into your calculations. Inrush currents can be significantly higher than steady-state currents and should be considered when selecting a fuse.

3 Select a Fuse Type: Choose the type of fuse that suits your application. Common types include fast-acting, slow-blow, and time-delay fuses. The choice depends on the circuit's characteristics and the type of protection needed.

4 Consult a Fuse Rating Chart: Refer to a fuse rating chart or table provided by the fuse manufacturer. These charts relate current rating (in amperes) to fuse wire size (usually specified in AWG or metric gauge).

5 Calculate the Minimum Fuse Rating: Use the calculated maximum current from step 1 as a basis and select a fuse with a rating slightly higher to ensure that it will safely carry the current without nuisance tripping.

6 Account for Voltage and Circuit Type: Ensure that the selected fuse is rated for the circuit's voltage and type (AC or DC). Fuses may have different voltage ratings, and using the correct type is crucial for safety.\

7 Check Temperature and Ambient Conditions: Consider the operating temperature and environmental conditions where the fuse will be installed. Some fuses may require derating if subjected to high temperatures.

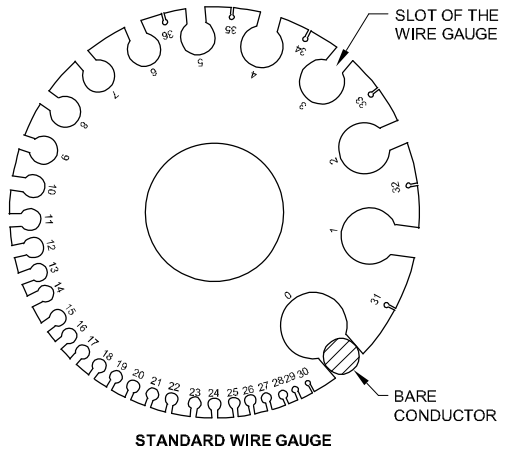
8 Install and Test: Once you've selected the appropriate fuse, install it in the circuit and perform tests to ensure proper operation under various conditions.

9 Documentation: Maintain records of the fuse size and its location in the circuit for future reference and safety documentation.

10 Regular Inspections: Periodically inspect and test the fuse to ensure it continues to provide the necessary protection.

It's crucial to follow safety guidelines and consult with electrical professionals or the fuse manufacturer when in doubt, as improper fuse selection can lead to circuit damage or safety hazards.

Fig 1



STANDARD WIRE GAUGE

Gauge	Max Amps	Recomened Fulse Size	Maximum Fuse Size
16	20	25	30
14	25	3125	37.5
12	35	43.75	52.5
10	45	56.25	67.5
8	60	75	90
6	80	100	120
4	120	150	180
2	160	200	240
1	210	262.5	315
0	245	306.25	387.5
1.0	285	358.25	427.5
2.0	330	412.5	495
3.0	385	481.25	577.5
4.0	445	555.25	667.5
BASED ON 105^0 C WIRE INSULATION			

Practice reading of energy flow diagram

Objectives: At the end of this exercise you shall be able to
- **reading of energy flow diagram.**

Requirements

Tools/Instruments

• A3 paper	- 4 Nos.
• Pencil HB	- 1 No.
• Scale 30 cm	- 1 No.

Materials/Components

• 4 Rubber	- 1 No.
• Energy flow diagram	- 1 copy.
•	

PROCEDURE

TASK 1:

1 **Study the Diagram :** Start by closely examining the energy flow diagram. Identify key components such as energy sources (e.g., coal, solar), conversion processes (e.g., combustion, photovoltaic cells), and end uses (e.g., electricity generation, heating).

2 **Label Components:** Begin by labeling each component in the diagram. Write down the names of energy sources, devices, and conversions involved. This will help you understand the flow of energy.

3 **Direction of Flow:** Determine the direction of energy flow. Energy typically flows from the source to the conversion process and then to the end use. Arrows in the diagram usually indicate this direction.

4 **Quantify Flows:** If possible, identify and quantify the energy flows between components. This may involve using numbers or labels to represent energy quantities, such as kilowatts (kW) or percentages.

5 **Analyze Efficiency :** Pay attention to efficiency percentages, if mentioned in the diagram. Efficiency indicates how effectively energy is converted from one form to another. Higher efficiency values indicate less energy loss.

6 **Calculate Totals :** Calculate the total energy input and output at different stages of the system. This can help you understand how energy is conserved or lost throughout the process.

7 **Identify Feedback Loops :** Some systems have feedback loops, where the output of one component affects another. Look for such loops and understand how they impact the overall energy flow.

8 **Make Annotations :** Use your paper or digital tool to draw additional arrows, notes, or calculations on the diagram. This can help you visualize the energy flow more clearly.

9 **Practice Comparisons :** Compare different energy flow diagrams for various systems or scenarios. This will enhance your ability to interpret and analyze them effectively.

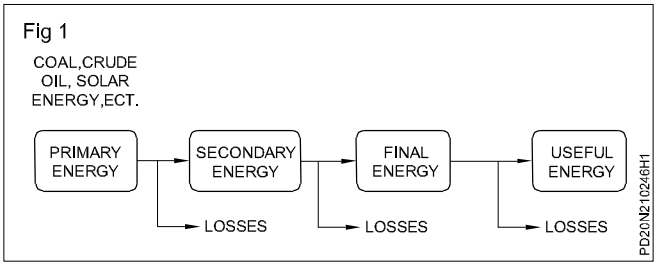
10 **Seek Guidance :** If you encounter unfamiliar components or concepts, don't hesitate to seek guidance from textbooks, experts, or online resources.

11 **Quiz Yourself :** Test your understanding by covering parts of the diagram and trying to recall the components and their interactions.

12 **Practice Regularly :** The key to mastering energy flow diagrams is practice. The more diagrams you work with, the better you'll become at reading and interpreting them.

By following these procedural steps and regularly practicing with different energy flow diagrams, you can improve your skills in understanding and analyzing complex energy systems. (Fig 1)

Fig 1



Test the control panel for its performance

Objectives: At the end of this exercise you shall be able to
- **test the control panel for any short circuit earthing with fitted devices**
- **test the earthing points connections with connected control devices**
- **energise and test the panel board for its working condition.**

Requirements

Tools/Equipments/Machines

- Trainees tool kit - 1 No.
- Megger 1000V - 1 No.

Materials/Components

- Connecting leads - as reqd.

PROCEDURE

The panel board used for the Ex.No. 2.1.135 is to be used for this Exercise with complete accessories and wiring.

1 Check the Insulation Resistance (IR) value of contactors circuit breakers etc, (Fig 1) enter the values in Table 1.

2 Check for any short circuit/open circuit fault.

If any IR value shows abnormal or very low, consult with your instructor.

3 Switch 'ON' the supply to the panel board and verify the functions of line indicator, meters etc.

4 Test the contactor, push button switch, timer for its function. Enter the status in Table 1.

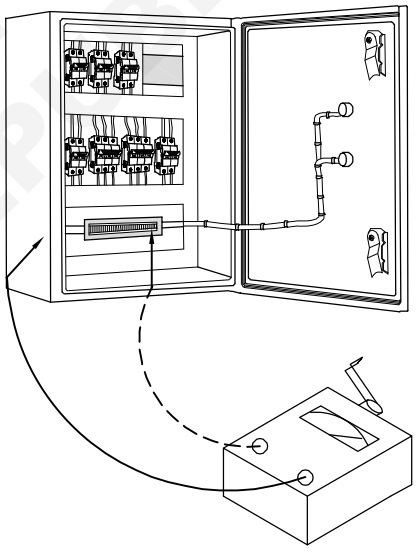
5 Switch 'on' the motor and check the functions of sensors (speed and temperature)

If any control device found faulty replace new control devices and test it.

The panel board with accessories and wiring is to be preserved for this Exercise No.2.10.247

6 Complete your testing and show to your instructor for approval.

Fig 1



TESTING OF PANEL BY MEGGER

PD20N210247H1

Table 1

Sl.No	Description of the items	Megger value in MΩ	Condition OK / not OK
1	Overload relay		
2	Contactor		
3	Circuit breaker		
4	Voltmeter		
5	Ammeter		
6	Frequency meter		
7	Temperature indicator		
8	Tachometer/revolution counter		
9	Indicators		

Identify various parts of relay and ascertain the operation

Objectives: At the end of this exercise you shall be able to
- **identify the external controls and parts of a electromagnetic relay**
- **identify the external parts of the single pole over current relay.**

Requirements

Tools/Equipment
- Trainees tool kit - 1 No.
- Single pole over current/earth fault relay with instruction manual - 1 No.

PROCEDURE

TASK 1 : **Identify external controls and parts of a electromagnetic relay**

1 Locate the relay parts provided in front of the relay (Fig 1) and identify the parts and fill in Table 1.

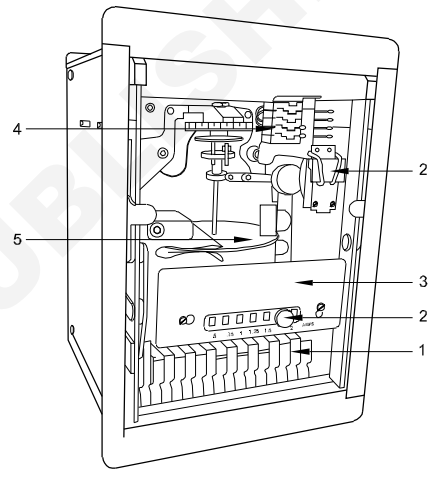
2 Note down the tap setting of current ranges at Table 2.

3 Note down in Table 2 the Indication displayed in the dial, multiplier along with percentage of fault current tripping time.

4 Locate the tripping. Flag indicator resetting level provided in front panel.

Once the relay tripped the flag will indicate a red line once it is tripped needs manual resetting by operating the lever.

Fig 1



SINGLE POLE OVER CURRENT RELAY

Table 1

Sl.No.	Part No.	Name of the external part	Function
1	1	Tripping flag indicator	Display tripping condition
2	2		
3	3		
4	4		
5	5		

Table 2

Sl.No	Current range	Multiplier of fault current	Time in seconds
1	Tap setting - 0.25A		

— — — — —

TASK 2 : **Identify internal parts of a single pole over current relay**

Instructor has to explain how to locate the internal parts and function of the circuit breaker and ask the trainees to tabulate the identified part of the available circuit breaker in your section.

1 Remove the front cover by loosening the four knobs provided in the corner of relay and preserve the cover with knobs carefully. (Fig 1)

Don't touch (or) try to operate any projected parts inside the relay.

2 Locate the aluminium disc fitted in the bottom of the spindle.

3 Locate the Time Multiplier Setting (TMS) fitted in the top of the spindle.

4 Check the divisions marked on the TMS disc used for time setting.

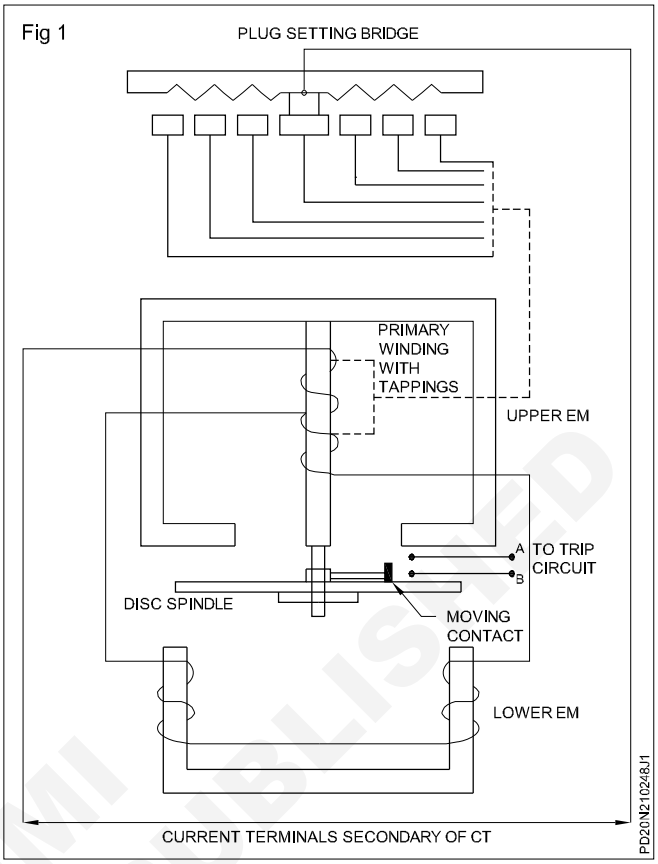
5 Locate the spiral spring mounted on the top of spindle to bring back the disc top its original position after tripping.

6 Locate the moving contact fitted along with the spindle on the top of disc enabling tripping circuit.

7 Locate the two terminals contact points acting as a switch to trip the circuit.

Do not allow any dust or tiny particles enter inside. Dust will deposit in the pinion and effect the disc movement.

Fig 1



8 Close the front panel and show the findings to your instructor.

9 Note down the identified parts in Table 1.

10 Get it checked by your instructor.

Table 1

Sl.No.	Part No.	Name of the internal part	Function

Practice setting of pick up current and time setting multiplier for relay operation

Objectives: At the end of this exercise you shall be able to
- **calculate the fault current in different percentage**
- **set up current in injector unit for different fault current**
- **set the pick up current of a 50% fault current**
- **set the time multiplier for time setting under various fault condition.**

Requirements

Tools/Equipments

- Trainees tool kit - 1 No.
- Over current relay with manual (used in previous Ex.No.4.7.203) - 1 No.
- Current injection unit with manual - 1 No.

PROCEDURE

TASK 1 : **Identify of pickup current and trip the relay for different fault current**

1 Identify the supply voltage required for operating over current relay to its tripping coil.

2 Identify the current input terminals of relay.

3 Identify the shorting pins of NC/NO relay contacts.

The current Injector unit is required to provide different fault current levels. The fault current settings is done in tap setting provided in the relay along with percentage of fault current with time.

4 Connect the tripping coil voltage and fault current connections from current injector to relay as per the manual instruction. Keep all the controls at zero position in current injector unit.

Some coils requires DC supply that can be taken from current injector unit.

5 Set the tap on relay for one amp. Calculate the multiplier from the dial and set the current in current injector unit. Record the values in Table 1.

Note : A sample reading is recorded in Table 1 on the tap setting at 1A; and multiplies value-2. Trip time displayed in dial an 10 seconds

Note : Select multiplier 2, so that the total fault current is 2 amp. ensure the time multiplier disc kept at position 1.

6 Note down the corresponding time displayed on the dial for multiplier 2.

The current injection unit have different makes and specifications . Energise the relay using manual supplied along with current injection unit.

7 Switch on the current injector unit ensure that relay is energised.

8 Increase slowly the current which is the input of relay to pickup.

Table 1

Sl. No.	TMS Position	Tap set current (a)	Multiplier value	Time in seconds current	Total fault current	Pickup Actual trip time
1	1	0.5	2 x 0.5 = 1A	10 Sec.	1A	<1A
2	1	1.0				
3	1	1.5				
4	1	2.0				

9 Increase the current slowly, the disc of relay start to move that is the pickup current. Note down the value in Table 1.

10 Change the tap set current to some other current value and repeat the step 5 to 9.

11 Change the tap set for other value and repeat the steps 6 to 10 and record the readings.

12 Try few more tap set values and check the pickup current.

TMS position should not be changed while doing the exercise.

— — — — — —

TASK 2 : **Reduce the tripping time by setting time multiplier setting**

1 Keep all the controls knobs at zero position.

2 Set the TMS disc at 0.5 position by rotating TMS disc fitted on the main spindle.

3 Repeat the steps 5 to 10 for the new TMS value of 0.5. Enter all the readings in Table 1.

Note : It may be noted that when TMS set for 0.5 the actual trip time reduced by 50% of the trip time actual in Task 1.

Table 1

Sl. No.	TMS Position	Tap set current (a)	Multiplier value	Time in seconds	Total fault current	Pickup current	Actual trip time
1	0.5	0.5 A	2 x 0.5 = 1A	10 Sec.	1A	<1A	
2	0.5	1.0 A	1.0 A				
3	0.5	1.5 A					
4	0.5	2 A					

— — — — — —

Interpret single line/ layout drawings with equipment and protection code as per ANSI

Objectives: At the end of this exercise you shall be able to
- **interpret Single line/Layout drawings with Equipment and protection codes as per ANSI.**

Requirements

Tools/Instruments

- A3 sheets - 5 Nos.
- Pen, pencil, rubber, scale - as reqd.
- PPE kit - as reqd.
- Layout/ single line drawing - 1 No.

Materials

- ANSI standard

PROCEDURE

- **Review the Drawing** Carefully examine the single-line or layout drawing. Understand the overall layout of the electrical system.
- **Identify Equipment** Locate and identify the various electrical equipment, such as circuit breakers, transformers, switches, and relays, on the drawing.
- **Read Protection Codes:** Look for protection codes associated with each plece of equipment. These codes typically include ANSI standards that govern their design and operation.
- **Understand Equipment Symbols:** Familiarize yourself with ANSI-compliant symbols used in the drawing. These symbols represent different types of equipment and their functions.
- **Analyze Electrical Connections:** Study how the equipment is interconnected. Follow the lines and symbols to trace the flow of electrical power through the system.
- **Check for Labels and Annotations:** Pay attention to any labels, annotations, or notes on the drawing. These may provide additional information about specific equipment or protection schemes.
- **Verify Compliance:** Ensure that the equipment and protection schemes depicted on the drawing comply with ANSI standards. Cross-reference the codes with the relevant ANSI standards documents.
- **Safety Considerations** Always prioritize safety. Identify safety features, such as disconnect switches and protective relays, and make sure they are correctly represented on the drawing.
- **Document Findings** Take notes or create a summary of your findings. Include any discrepancies or areas where the drawing may not align with ANSI standards.
- **Consult Experts (if needed)** If you encounter complex or ambiguous situations, consult with experts in electrical engineering or ANSI standards to ensure accurate interpretation.
- **Report and Recommendations:** Prepare a report or recommendations based on your analysis. Highlight any non-compliance issues and suggest corrective actions if necessary.
- **Review and Approval** Share your findings with relevant stakeholders for review and approval, Make any necessary revisions based on their feedback.
- **Implementation:** Once approved, ensure that any recommended changes or corrections are implemented in the electrical system.

Remember that interpreting electrical drawings with ANSI codes requires a strong foundation in electrical engineering principles and ANSI standards, It's crucial to approach this task with precision and attention to detail to ensure the safety and reliability of the electrical system.

Construction of Single Line diagram:

- Single the diagram is a simplified notation for representing a three-phase power system, instead of representing each of three phases with separate line or terminal, only one conductor a represented
- Electrical elements such as circuit breakers, transformers, capacitors, but bars, and conductors are shown by standardized schematic symbols
- Elements on the diagram do not represent the physical size or location of the electrical equipment
- On one - line power diagrams, components are usually arranged in order of decreasing voltage levels. The highest voltage component is shown at

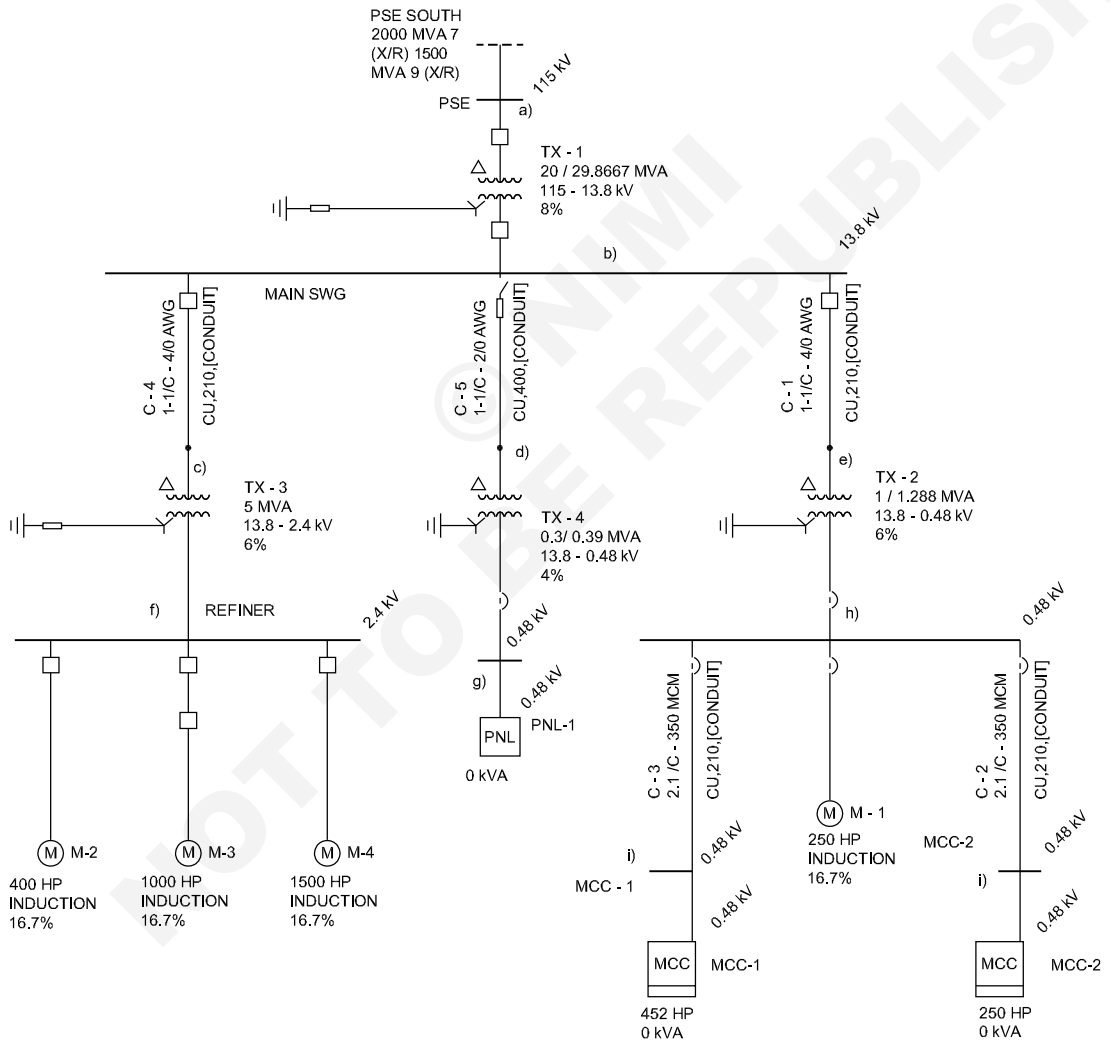
the right of the drawing, in order to find out how power is supplied to a component, start at the component and trace the fiaw of power backwards through the drawing. This method will be most useful is locating the correct circuit breaker to isolate a component for maintenance

- You can read the single tine diagram from the top to the bottom or from left to right of the diagram.
- Manufacturers type designation, and rating of devices
- Ratios of current and power transformers, taps to be used in multi-ratio transformers, and connections of double-ratis transformers.
- Rating connections of wye and delta power transformer windings
- Circuit breaker ratings in volts and amperes.
- The interrupting rating, type, and number of trip coils on circuit breakers
- Switch and fine ratings in volts and amperes
- Function of relays
- The sizes, type, and number of incoming and outgoing cables
- The voltage, phase, and frequency of incoming and outgoing circuits. The aratable short circuit and pround cures of the power company system, and type at ground used.
- Metered points and type of matering
- The amount of the load on all feeders.

Devtion a mosle line diagram (as per IEEE and ANSI)

to be familiar with the method of single line development by ANSI and IEEE you should know the following items :

Fig 1



Abbreviations

Abbr.	Description		Abbr.
AM	Ammeter	S	Synchronous motor
AS	Ammeter switch	S/A	Surge arrester
AUX	Auxiliary	SS	Synchronizing switch
BKR	Breaker	SYN	Synchroscope
CO	Cut off switch	SYN BR	Synchronizing bracket
CPT	Control power transformer	TD	Test device
CS	Control switch	VAR	Varmotor (one-line)
CT	Current transformer	VAR,	Varmeter (device list)
FA	Field ammotor	VM	Voltmeter
FM	Frequency meter	VR	Voltage regulator
G	Generator	VS	Voltmeter switch
GS	Govemor switch	WHM	Watthour meter
I	Induction motor	WHDM	Watthour demand center

ANSI standard device numbers & commom acronyms

Device No.	Description
1	Master Element
2	Time Delay Starting or Closing Relay
3	Checking or Interlocking Realy
4	Master Contactor
5	Stopping Device
6	Starting Circuit Breaker
7	Rate of Change Relay
8	Control Power Disconnecting Device
9	Reversing Device
10	Unit Sequence Switch
11	Multifunction Device
12	Overspeed Device/Protection
13	Synchronous-Speed Device
14	Underspeed Device
15	Speed or Frequency Matching Device
16	Communication Networking Device
17	Shunting or Discharge Switch
18	Accelerating or Decelerating Device
19	Motor Starter/Starting-to-Running Transition Contactor
20	Electrically-Operated Valve
21	Distance Relay
21G	Ground Distance
21P	Phase Distance
22	Equalizer Circuit Breaker
23	Temperature Control Device
24	Volts-per-Hertz Relay / Overfluxing

Device No.	Description
25	Synchronizing or Synchronism-Check Device
26	Apparatus Thermal Device
27	Undervoltage Relay
27P	Phase Undervoltage
27TN	Third Harmonic Neutral Undervoltage
27X	Auxiliary Undervoltage
27 AUX	Undervoltage Auxiliary Input
27/ 27X	Bus/Line Undervoltage
28	Flame Detector
29	Isolating Contactor
30	Annunciator Relay
31	Separate Excitation Device
32	Directional Power Relay
32L	Low Forward Power
32N	Wattmetric Zero-Sequence Directional
32P	Directional Power
32R	Reverse Power
33	Position Switch
34	Master Sequence Device
35	Brush-Operating or Slip-ring Short Circuiting Device
36	Polarity or Polarizing Voltage Device
37	Undercurrent or Underpower Relay
37P	Underpower
38	Bearing Protective Device / Bearing Rtd
39	Mechanical Condition Monitor
40	Field Relay / Loss of Excitation.
41	Field Circuit Breaker

Device No.	Description
42	Running Circuit Breaker
43	Manual Transfer or Selector Device
44	Unit Sequence Starting Relay
45	Atmospheric Condition Monitor
46	Reverse-Phase or Phase Balance Current Relay or Stator Current Unbalance
47	Phase-Sequence or Phase Balance Voltage Relay
48	Incomplete Sequence Relay / Blocked Rotor
49	Machine or Transformer Thermal Relay / Thermal Overload
49RTD	RTD Biased Thermal Overload
50	Instantaneous Overcurrent Relay
50BF	Breaker Failure
50DD	Current Disturbance Detector
50G	Ground Instantaneous Overcurrent
50N	Neutral Instantaneous Overcurrent
50P	Phase Instantaneous Overcurrent
50_2	Negative Sequence Instantaneous Overcurrent
50/27	Accidental Energization
50/74	Ct Trouble
50/87	Instantaneous Differential
50EF	End Fault Protection
50IG	Isolated Ground Instantaneous Overcurrent
50LR	Acceleration Time
50NBF	Neutral Instantaneous Breaker Failure
50SG	Sensitive Ground Instantaneous Overcurrent
50SP	Split Phase Instantaneous Current
51	Ac Time Overcurrent Relay
51	Overload
51G	Ground Time Overcurrent
51N	Neutral Time Overcurrent
51P	Phase Time Overcurrent
51V	Voltage Restrained Time Overcurrent
51R	Locked/Stalled Rotor

Suffixes	Description
_1	Positive-Sequence
_2	Negative-Sequence
A	Alarm, Auxiliary Power
AC	Alternating Current
AN	Anode
B	Bus, Battery, or Blower

Suffixes	Description
BF	Breaker Failure
BK	Brake
BL	Block (Valve)
BP	Bypass
BT	Bus Tie
BU	Backup
C	Capacitor, Condenser, Compensator, Carrier Current, Case, or Compressor
CA	Cathode
CH	Check (Valve)
D	Discharge (Valve)
DC	Direct Current
DCB	Directional Comparison Blocking
DCUB	Directional Comparison Unblocking
DD	Disturbance Detector
DUTT	Direct Underreaching Transfer Trip
E	Exciter
F	Feeder, Field, Filament, Filter, or Fan
G	Ground or Generator
GC	Ground Check
H	Heater or Housing
L	Line or Logic
M	Motor or Metering
MOC	Mechanism Operated Contact
N	Neutral or Network
O	Over
P	Phase or Pump
PC	Phase Comparison
POTT	Pott: Permissive Overreaching Transfer Trip
PUTT	Putt: Permissive Underreaching Transfer Trip
R	Reactor, Rectifier, or Room
S	Synchronizing, Secondary. Strainer, Sump, or Suction (Valve)
SOTF	Switch On To Fault
T	Transformer or Thyratron
TD	Time Delay
TDC	Time-Delay Closing Contact
TDDO	Time Delayed Relay Coil Drop-Out
TDO	Time-Delay Opening Contact
TDPU	Time Delayed Relay Coil Pickup
THD	Total Harmonic Distortion
TH	Transformer (High-Voltage Side)
TL	Transformer (Low-Voltage Side)
TM	Telemeter
TT	Transformer (Tertiary-Voltage Side)

Suffixes	Description
U	Under or Unit
X	Auxiliary
Z	Impedance

Acronyms	Description
AFD	Arc Flash Detector
CLK	Clock or Timing Source
CLP	Cold Load Pickup
DDR	Dynamic Disturbance Recorder
DFR	Digital Fault Recorder
ENV	Environmental Data
HIZ	High Impedance Fault Detector
HMI	Human Machine Interface
HST	Historian
MET	Substation Metering
PDC	Phasor Data Concentrator
PMU	Phasor Measurement Unit
PQM	Power Quality Monitor
RIO	Remote Input/Output Device
RTD	Resistance Temperature Detector
RTU	Remote Terminal Unit / Data Concentrator
SER	Sequence of Events Recorder
TCM	Trip Circuit Monitor
VTFF	Vt Fuse Fail

Device No.	Description
51_2	Negative Sequence Time Overcurrent
52	Ac Circuit Breaker
53	Exciter or Dc Generator Relay
54	Turning Gear Engaging Device
55	Power Factor Relay
56	Field Application Relay
57	Short-Circuiting or Grounding Device
58	Rectification Failure Relay
59	Overvoltage Relay
59B	Bank Phase Overvoltage
59P	Phase Overvoltage
59N	Neutral Overvoltage
59NU	Neutral Voltage Unbalance
59P	Phase Overvoltage
59X	Auxiliary Overvoltage
59_2	Negative Sequence Overvoltage
60	Voltage or Current Balance Relay
60N	Neutral Current Unbalance
60P	Phase Current Unbalance
61	Density Switch or Sensor

Device No.	Description
62	Time-Delay Stopping or Opening Relay
63	Pressure Switch Detector
64	Ground Protective Relay.
64F	Field Ground Protection
64S	Sub-harmonic Stator Ground Protection
64TN	100% Stator Ground
65	Governor
66	Notching or Jogging Device/Maximum Starting Rate/Starts Per Hour/Time Between Starts
67	Ac Directional Overcurrent Relay
67G	Ground Directional Overcurrent
67N	Neutral Directional Overcurrent
67P	Phase Directional Overcurrent
67SG	Sensitive Ground Directional Overcurrent
67_2	Negative Sequence Directional Overcurrent
68	Blocking Relay / Power Swing Blocking
69	Permissive Control Device
70	Rheostat
71	Liquid Switch
72	Dc Circuit Breaker
73	Load-Resistor Contactor
74	Alarm Relay
75	Position Changing Mechanism
76	Dc Overcurrent Relay
77	Telemetering Device
78	Phase Angle Measuring or Out-of-Step Protective Relay
78V	Loss of Mains
79	Ac Reclosing Relay / Auto Reclose
80	Liquid or Gas Flow Relay
81	Frequency Relay
81O	Over Frequency
81R	Rate-of-Change Frequency
81U	Under Frequency
82	Dc Reclosing Relay
83	Automatic Selective Control or Transfer Relay
84	Operating Mechanism
85	Carrier or Pilot-Wire Receiver Relay
86	Locking-Out Relay
87	Differential Protective Relay
87B	Bus Differential
87G	Generator Differential
87GT	Generator/Transformer Differential

Device No.	Description
87LG	Ground Line Current Differential
87S	Stator Differential
87S	Percent Differential
87L	Segregated Line Current Differential
87M	Motor Differential
87O	Overall Differential
87PC	Phase Comparison
87RGF	Restricted Ground Fault
87T	Transformer Differential
87V	Voltage Differential
88	Auxiliary Motor or Motor Generator
89	Line Switch
90	Regulating Device
91	Voltage Directional Relay
92	Voltage And Power Directional Relay
93	Field-Changing Contactor
94	Tripping or Trip-Free Relay
50/74	Ct Supervision
27/50	Accidental Generator Energization
27TN/ 59N	100% Stator Earth Fault

- Each device in an automatic switching equipment has a device function number (see fig.2) which is placed adjacent to or within the device symbol or all wiring diagrams and arrangement drawings so that its function and operation may be readily identified.
- These numbers are based on a system which was adopted as standard for Automatic Switchgear by the American National Standards Institute (ANSI C37.2).

Three steps are used in producing a one-line diagram (as per IEEE and ANSI):

1 The preliminary one-Line diagram,

2 The partially developed diagram,

3 The developed diagram.

Interpret layout drawing of 400KV/ 132 KV/ 66 KV/ 33 KV/ 11 KV outdoor substation

Objectives: At the end of this exercise you shall be able to
- **interpret layout drawings of 400KV/220KV/132KV/66KV/33KV/11KV out door substations.**

Requirements

Tools/Instruments

- Layout of drawing
- Site plan of substation
- Equipment layout
- Cable routing sketch

Materials

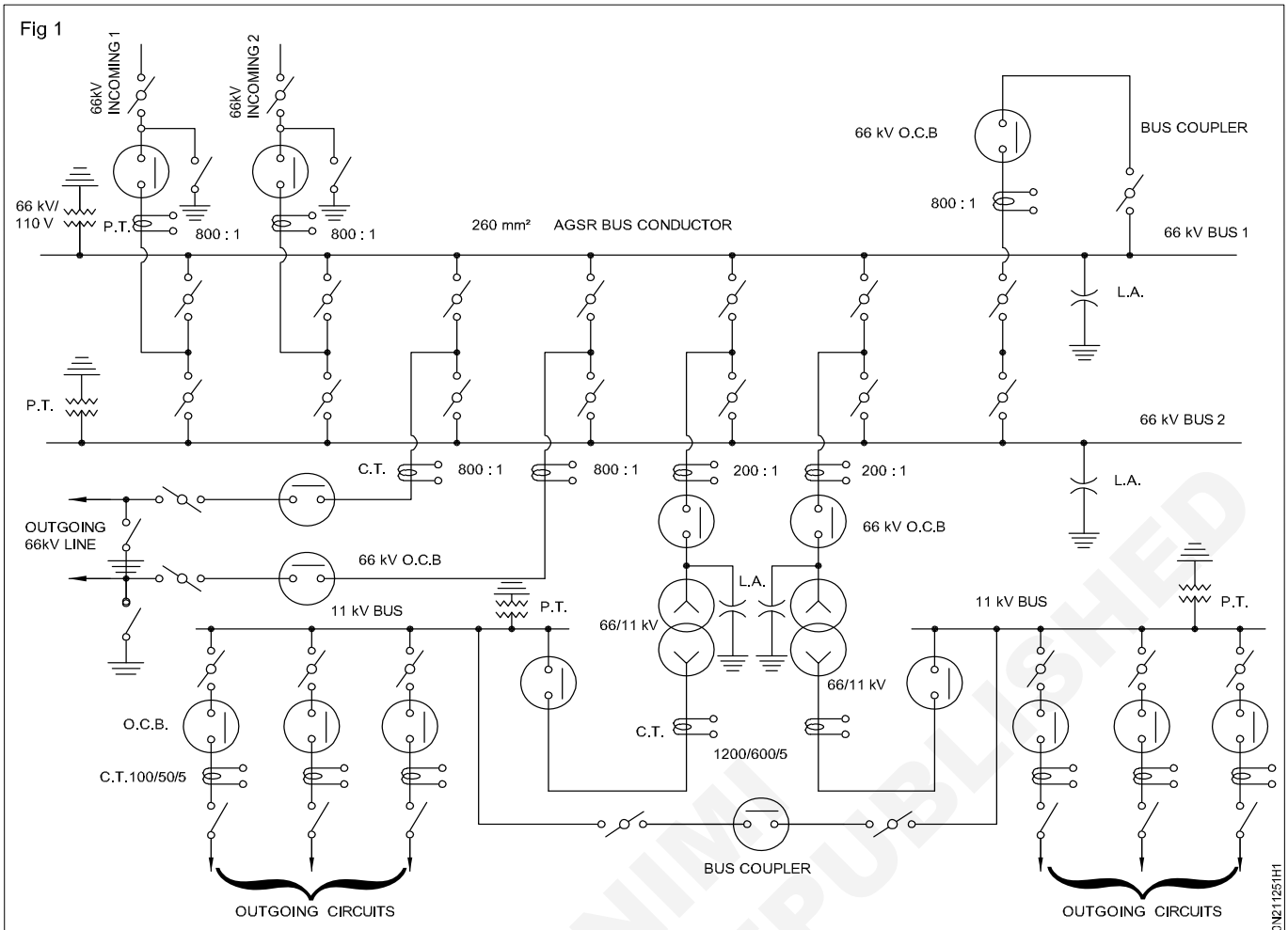
- A3 paper - 8 Nos
- Pen, pencil, scale, rubber - as reqd

PROCEDURE

- **Review the Title Block:** Start by examining the title block of the drawing. It typically contains essential information such as the project name, drawing number, revision date, and the name of the designer or engineer.
- **Scale and Units:** Check the scale of the drawing to ensure you understand the size and distances accurately. Also, verify the units used (e.g.. meters, feet) and confirm that your measurements align with the drawing's scale.
- **Orientation:** Determine the north direction on the drawing, as this will help you understand the layout's geographical orientation.
- **Site Plan:** Begin with the site plan. Identify the boundaries of the substation, access roads, fencing, and any other external features. Note the location of any neighboring structures, if applicable.
- **Equipment Layout:** Focus on the equipment layout. Identify the placement of transformers, circuit breakers, switches, disconnectors, and other major components. Pay attention to their sizes and distances from each other.
- **Busbars and Conductors:** Trace the routes of busbars and conductors connecting various components. Understand how power flows within the substation.
- **Safety Features:** Identify safety features like fire suppression systems, emergency exits, and safety barriers. Ensure compliance with safety codes and regulations.
- **Grounding and Earthing:** Check the grounding and earthing arrangements, including the location of ground grids, grounding electrodes, and bonding conductors.
- **Protection and Control:** Examine the control build ing or panels to understand the protection and con trol systems used in the substation. Note the location of relays, control panels, and communication equipment.
- **Cable Routing:** Analyze the cable routing and trench layouts. Understand how power and control cables are routed within the substation.
- **Lightning Protection:** Identify lightning protection measures, including lightning rods or masts and their grounding systems.
- **Environmental Considerations:** Note any environmental considerations, such as drainage systems or provisions for mitigating environmental impact.
- **Compliance:** Ensure that the substation layout complies with local, national, and international electrical codes and standards.
- **Documentation:** Keep detailed notes as you review the drawing, and cross-reference them with the provided documentation to ensure accuracy.
- **Consult Experts:** If you encounter complex or unfamiliar elements, consult with experienced electrical engineers or substation designers for guidance.
- **As-Built Drawings:** Finally, compare the layout drawing with as-built drawings to verify that the constructed substation matches the design.

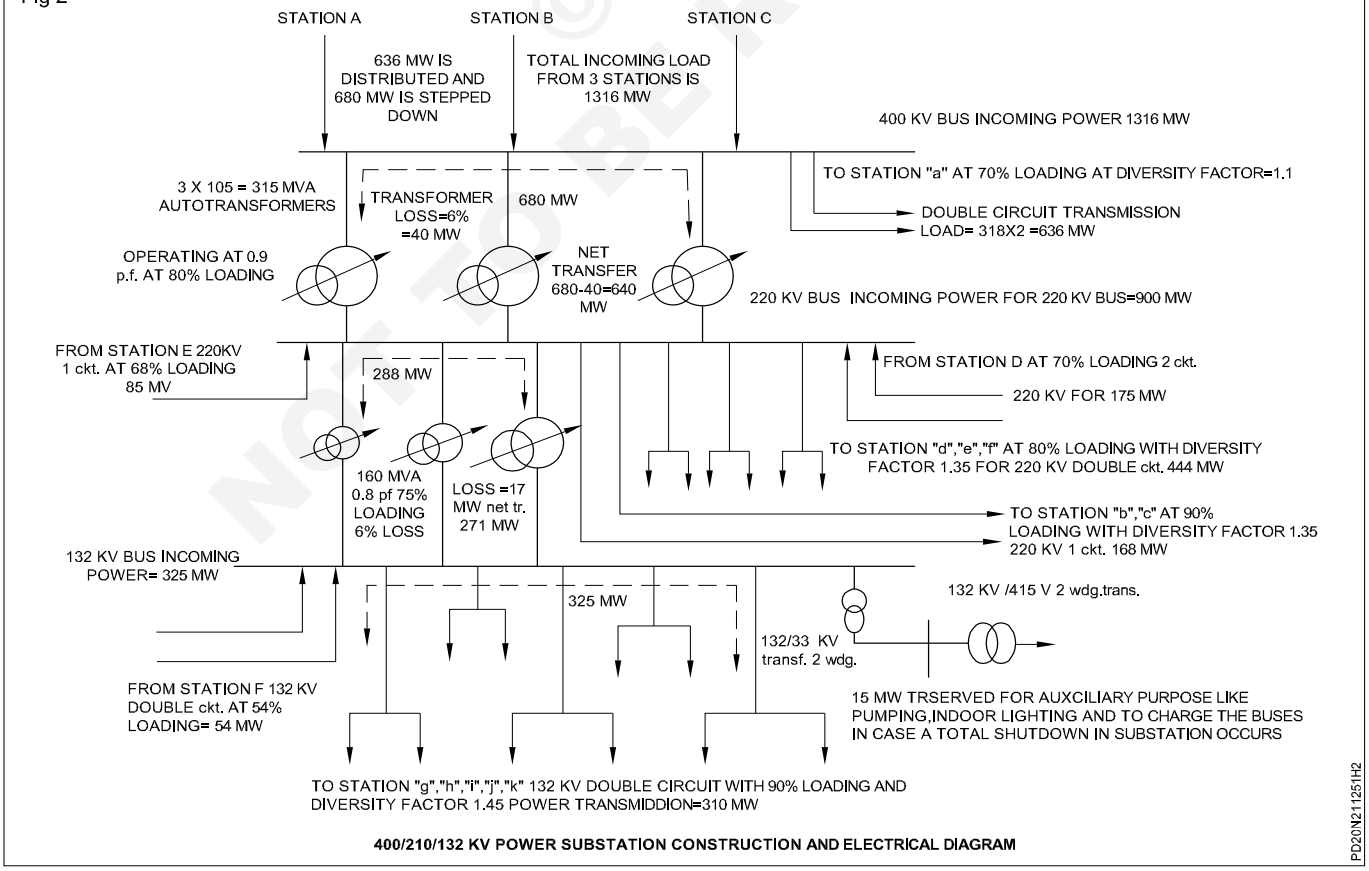
Interpreting layout drawings for outdoor substations is a critical task, as it directly impacts the safety and functionality of the electrical infrastructure. Always prioritize safety and compliance with relevant standards throughout the interpretation process.

Fig 1



KEY DIAGRAM OF 66/11 kV SUB-STATION

Fig 2



400/210/132 KV POWER SUBSTATION CONSTRUCTION AND ELECTRICAL DIAGRAM

Interpret various panel wring drawing of substation equipment

Objectives: At the end of this exercise you shall be able to
- **interpret various panel wiring drawing of substation equipment**

Requirements

Tools/Instruments

- Schematic drawings of power and control units of the substation
- Pencil - 1 No.
- Scale - 1 No.
- Rubber - 1 No.
- A3 papper - 4 Nos.

PROCEDURE

1 Gather Documentation: Collect all relevant documentation, including the wiring diagram, equipment manuals, and any related drawings.

2 Identify Components: Start by identifying the various components in the panel wiring diagram. Locate items like transformers, circuit breakers, relays, and control devices.

3 Study Wiring Paths Follow the wiring paths and connections between components. Pay attention to line numbers, color codes, and labels used for wires

4 Understand Control Logic: Analyze the control logic represented in the diagram. Determine how signals flow between components and what conditions trigger specific actions.

5 Safety Precautions Ensure that you understand safety precautions and isolation points. Always follow safety guidelines when working with electrical equipment.

6 Check for Updates Verify that the wiring diagram matches the actual equipment configuration. Substation equipment may be modified or upgraded over time, so confirm that the documentation is up-to-date.

7 Trace Circuits: Trace individual circuits from the power source to loads, noting the purpose and function of each circuit.

8 Troubleshooting: If you encounter discrepancies or issues in the wiring, use your knowledge of electrical systems to troubleshoot and resolve them.

9 Documentation: Document any changes or corrections you make to the wiring diagram. This ensures that future users have accurate information.

10 Testing If necessary perform functional tests to ensure that the equipment operates as intended based on the wiring diagram.

11 Review Standards Double-check that the wiring conforms to relevant electrical standards and codes.

12 Training: If you are part of a team, ensure that others involved in the substation's operation are trained to understand the wiring diagrams and procedures.

Interpreting panel wiring drawings in a substation is a critical task that requires precision and adherence to safety protocols. Always consult with experienced professionals or engineers if you encounter complex or unfamiliar diagrams.

To make the wiring easier to install, the location of the wires on the wiring diagram should correspond to their proposed location inside the relay and control panel.

Each multicore cable should have an identification number. In addition, every conductor in each cable should be numbered. It is useful if the numbering of multicore cables is carried out consecutively by voltage level. With this in mind, an ample range of numbers should be provided, for example, multiples of 100 for each voltage level, thus ensuring that there are sufficient spare consecutive numbers available for any additional cabling in the future.

These diagrams represent in order to show in a structured manner the behavior of the substation protection system for any contingency

Cabling lists provide information on the multicore cables that run between various items of equipment and help to make it easier to verify the substation wiring for maintenance work

diagram of AC connections generally shows the three-phase arrangement of the substation power equipment, and the AC circuits associated with the measurement, control and protection equipment, in schematic form

Each diagram should include all equipment corresponding to a bay. In CT current circuits, only the current coils of the measurement instruments and the protection relays should be drawn, indicating clearly which coils are connected to each phase and which to the neutral. The polarity of equipment should be indicated on the drawings.

Solid-state protection relays should be represented schematically by squares, showing the number of terminals and the method of connecting the wiring carrying the voltage and current signals. The points where a exists should also be indicated in this diagram, for example, when the neutral of the measurement transformers is connected in star.

The main nominal characteristics should be marked close to each item of equipment.

For example, for power transformers, the voltage ratio, power rating and vector group should be provided, for power circuit breakers, the nominal and short-circuit current ratings; the transformation ratios for voltage and current transformers, and the nominal voltage of lightning arresters.

As a minimum, the AC diagram of a transformer should include all the equipment in the bay between the high voltage busbar and the secondary bushings of the transformer

Diagrams of DC connections illustrate and should clearly show the various connections to the DC auxiliary services.

A diagram of connections for all substation equipment that take supplies from the DC system should be provided.

The positive infeeds are normally shown at the top of the diagram, and the negative ones at the bottom, and, as far as possible, the equipment included in the diagrams should be drawn between the positive and negative busbars.

It is useful if the signaling and control equipment in the relay and control panel is located in one part of the diagram, and the protection equipment in another part. Every terminal should be uniquely identified on the drawing.

The internal circuits of the are not shown, since it is sufficient to indicate the tripping contacts and the points of interconnection with other equipment inside a dotted rectangle. Given the complexity of, it might be necessary to make a separate diagram to indicate their connections to the DC system and the interconnection of the terminals. It is also possible that separate diagrams may be required for transformer and busbar differential protection.

One for feeding the protection equipment and a separate one for signaling purposes and controlling breakers and disconnectors. The two supplies should be kept independent of each other, and care should be taken to avoid connecting any equipment across the two DC supplies.

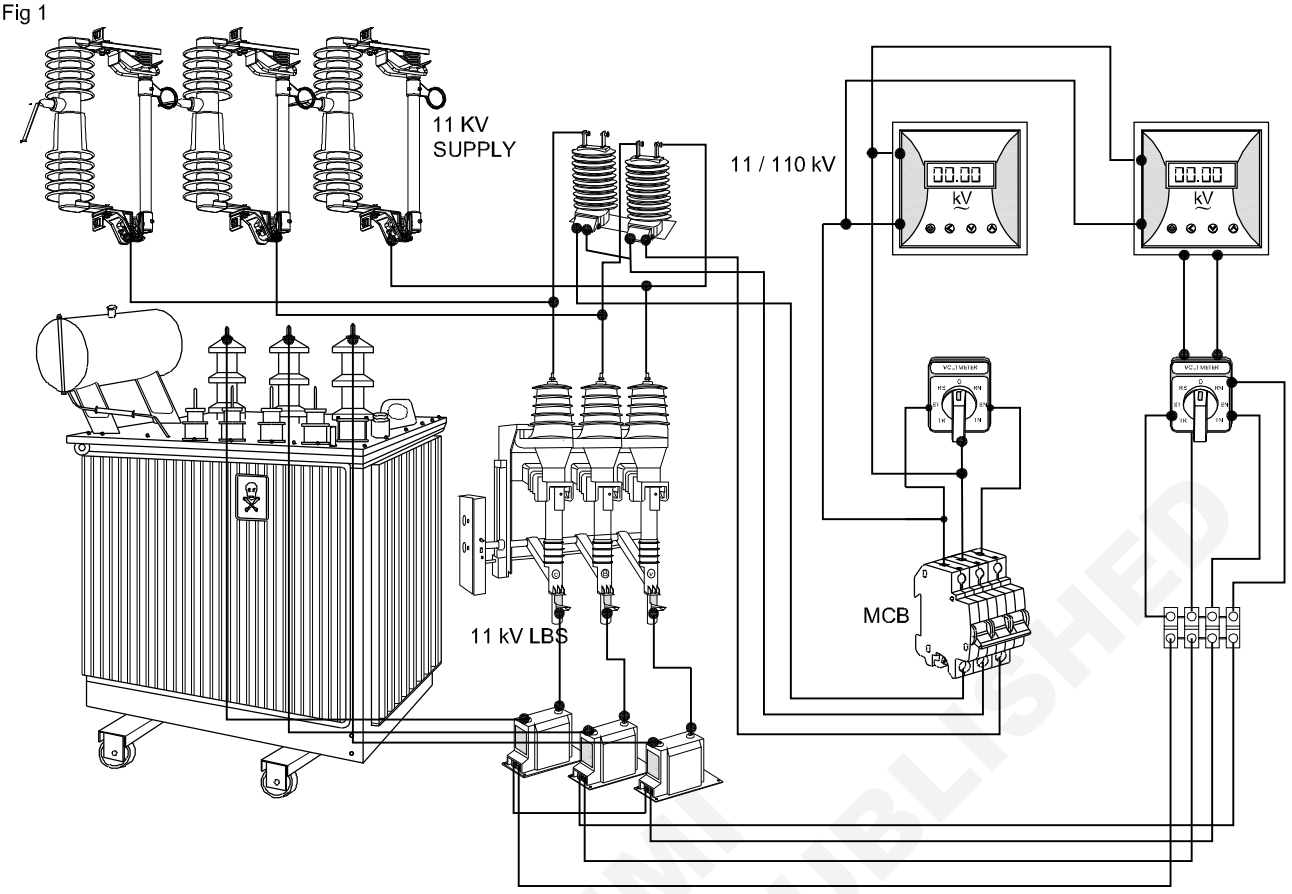
Wiring diagrams show. for example, between the switchgear and the associated control panels, and the routing of individual wires to the equipment installed in the relay and control panels.

These diagrams are required. The wiring should be carried out in accordance with the layout shown in the AC and DC diagrams

It is logical that the layout of the different devices on the wiring diagrams should be as seen, as in practice. Each device should be represented by its schematic, with every terminal located in accordance with its actual position on the panel.

Each conductor should be marked with the same identification code as the terminal to which it is connected, and also marked at each end with the location of the far end of the conductor, according to a predetermined code.

Fig 1



INSIDE WIRING 11 KV HT PANEL SUBSTATION

Identify various fire fighting equipment used in substations

Objectives: At the end of this exercise you shall be able to
- **Identify fire fighting equipments used in substation.**

Requirements

Tools/Instruments

• Fire Extinguisher	-1No.	• Fire suppression	-1No.
• Fire alarm system	-1No.	• Fire doors	-1No.
• Smoke detector	-1No.	• Emergency & safety	-1No.
• Heat detector	-1No.	• PPE kit	-1No.
• Fire Hydrant system	-1No.	• Gloves	-1No.
		• Eye glass	-1No.

PROCEDURE

1 Visit substation.

2 **Safety Precautions:** Before entering the substation, ensure you have the necessary safety gear, including appropriate clothing, gloves, and eye protection.

3 **Access Permission:** Obtain permission to access the substation from the relevant authorities or personnel responsible for the facility.

4 **Visual Inspection:** Walk around the substation and visually inspect for firefighting equipment. Look for red or conspicuously marked cabinets or containers.

5 **Fire Extinguishers:** Identify fire extinguishers. They are usually located at strategic points within the substation, such as near the entrance or control panels. Check their types (e.g., CO2, dry powder, foam) and their inspection tags for validity.

6 **Fire Hose Reels:** Locate fire hose reels or hydrants. These are typically placed around the perimeter or at specific locations. Ensure they are accessible and well-maintained.

7 **Fire Blankets:** Look for fire blankets, often stored near equipment that might involve electrical fires, like transformers or switchgear.

8 **Emergency Lighting:** Identify emergency lighting systems, which can guide you to safety during a fire. Ensure they are operational.

9 **Fire Alarm Systems:** Check for fire alarm pull stations and alarm bells or sirens. Confirm they are functional.

10 **Sprinkler Systems:** If present, locate and inspect automatic sprinkler systems. They are common in larger substations.

11 **Fire Suppression Systems:** Some substations may have specialized fire suppression systems, such as gas-based systems. Identify these and ensure they are properly maintained.

12 **Fireproofing Materials:** Be aware of fire-resistant coatings or materials applied to equipment or structures.

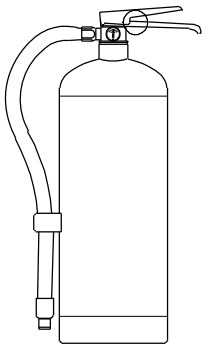
13 **Emergency Contacts:** Find a list of emergency contacts

- A smoke detector is a device that senses smoke, typically as an indicator of fire. Smoke detectors are usually housed in plastic enclosures,
- fire alarm is a unit made of several devices, which uses visual and audio signaling to warn people about a possible fire, smoke, or carbon monoxide occurrence in the area of coverage. Fire alarms are usually set in fire alarm systems to provide zonal coverage for residences and commercial buildings.
- Fire requires fuel, heat and oxygen to burn. Fire extinguishers apply an agent that will cool burning heat, smother fuel or remove oxygen so the fire cannot continue to burn
- heat detector is a fire alarm device designed to respond when the converted thermal energy of a fire increases the temperature of a heat sensitive element. The thermal mass and conductivity of the element regulate the rate flow of heat into the element.
- Fire suppression or firefighting is the procedure or activity of mitigating the results of fire that already has started
- Fire doors are designed to resist the spread of fire for a period of time, normally a minimum of 30 minutes.

This allows time for people to leave the building via an escape route if other routes are compromised in the event of a fire.

- Fire safety signs are designed to warn staff and visitors of any fire hazards, to provide an instruction or to give safety information. It is vital to provide clear and concise instructions about the actions to take in the case of a fire.

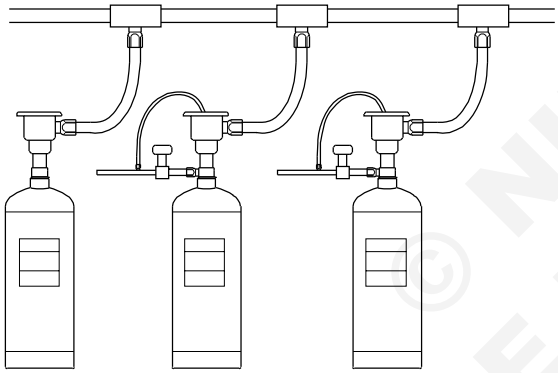
Fig 1



FIRE EXTINGUISHER

PD20N212253H1

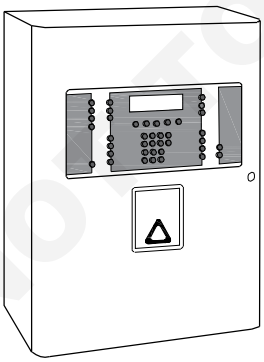
Fig 2



CO_2 SUPPRESSION SYSTEM

PD20N212253H2

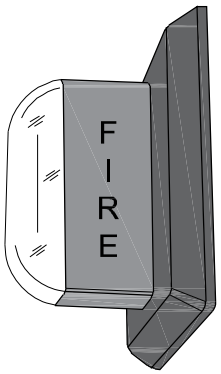
Fig 3



FIRE ALARAM CONTROL PANEL

PD20N212253H3

Fig 4



FIRE ALARAM

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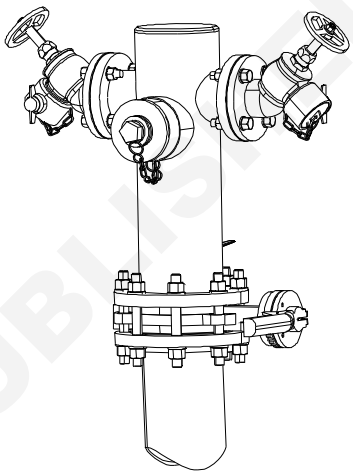
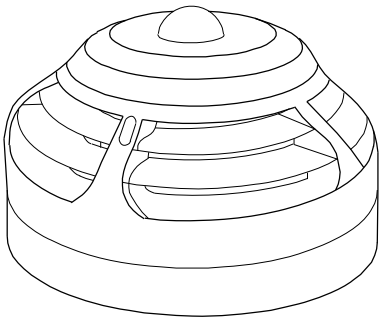
Fig 5



HYDRANT SYSTEM

PD20N212253H5

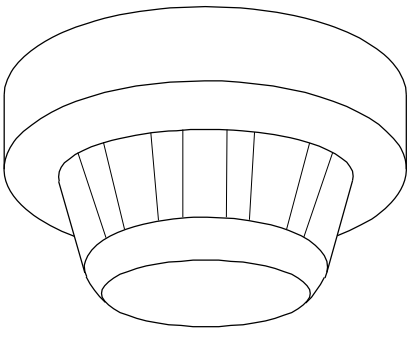
Fig 6



HEAT DETECTOR

PD20N212253H6

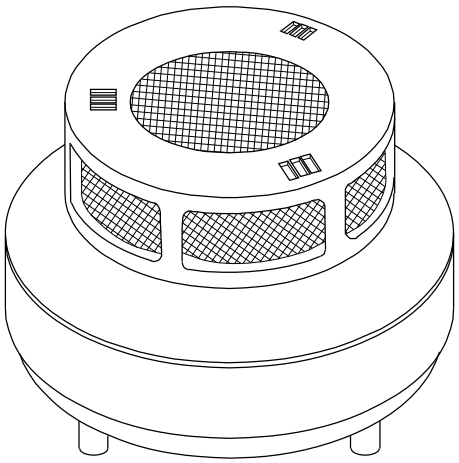
Fig 7



SMOKE DETECTOR

PD20N212253H7

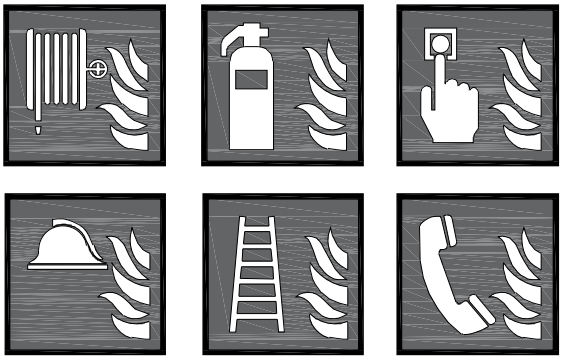
Fig 8



SMOKE DETECTOR

PD20N212253H8

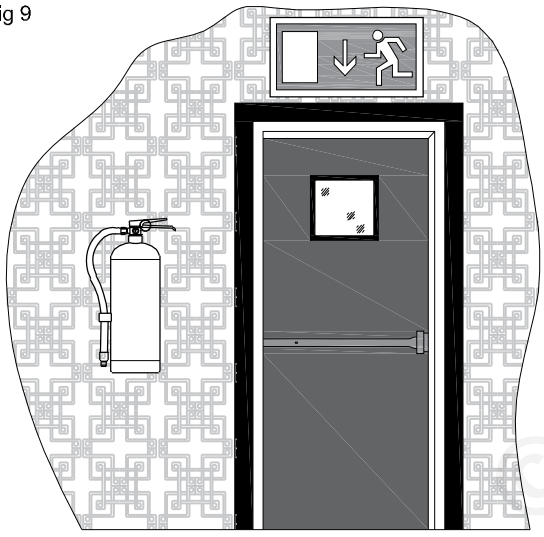
Fig 10



FIRE SYMBOLS

PD20N212253HA

Fig 9



FIRE DOORS

PD20N212253H9

Practice on different fire fighting extinguisher

Objectives: At the end of this exercise you shall be able to
- **select fire extinguishers according to the type of the fire**
- **operate the fire extinguishers**
- **extinguish the fire.**

Requirements

Tools and Instruments/equipment

- Fire extinguishers-CO2 - 1No.
- Scissors 100mm - 1No.
- Cell phone - 1No.
- Plain water Fire Extinguisher - 1No.
- Dry Power Are Extinguisher - 1No.
- Wet Chemical Fire Extinguisher - 1No.

PROCEDURE

TASK 1:

1 Alert people in the surrounding area by shouting fire, fire, fire when you see fire (Fig 1a).

2 Inform fire service or arrange to inform them immediately (Fig 1c).

3 Open the emergency exit and ask the people inside the area to go away (Fig 1d).

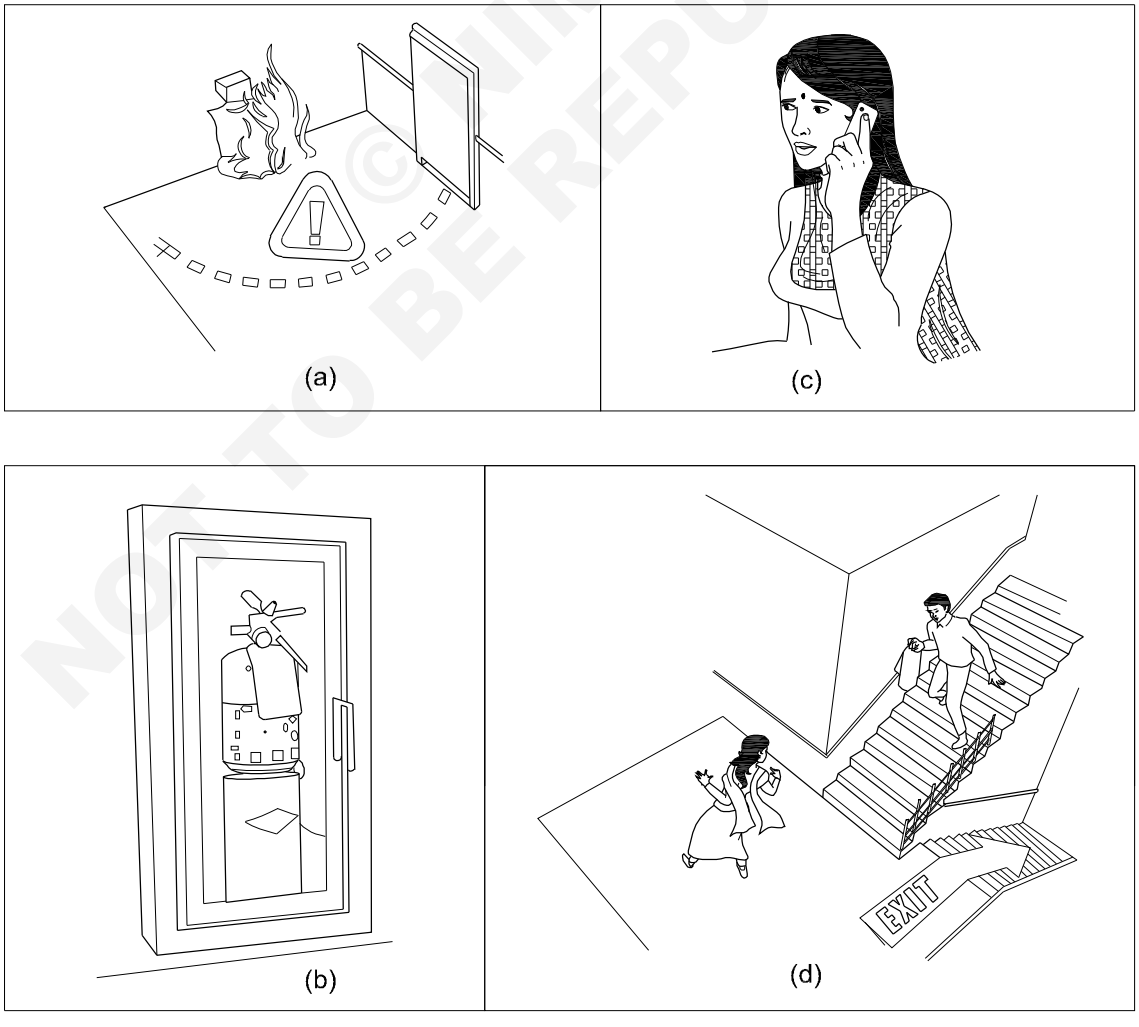
4 Switch “OFF” all electrical power supply.

Do not allow people to go near the fire.

5 Analyze to identify the type of fire. Refer Table1.

6 Assume that it is type D fire (fire on electric equipment).

Fig 1



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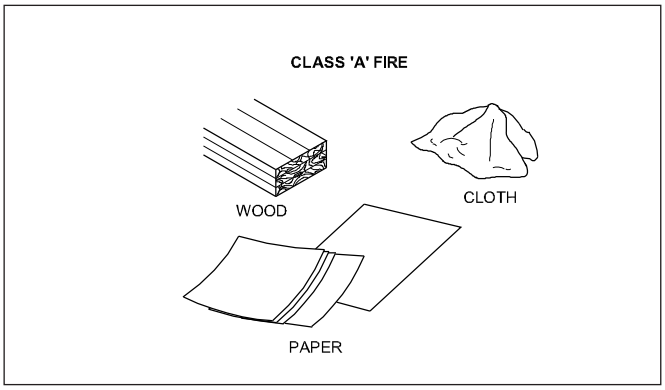
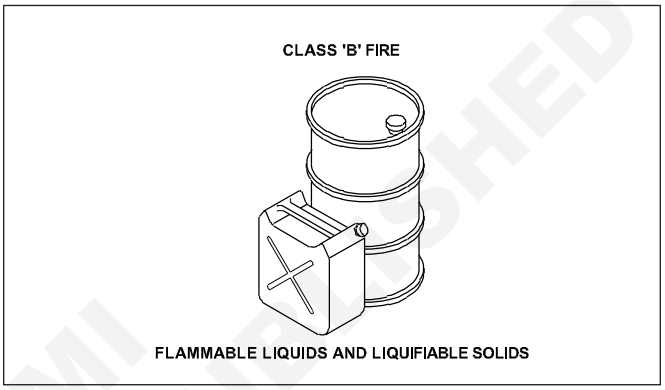
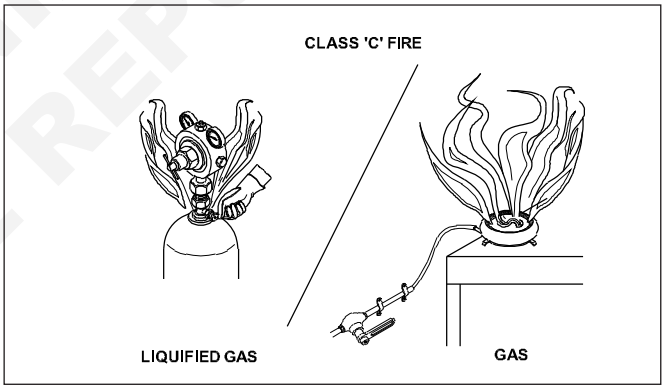
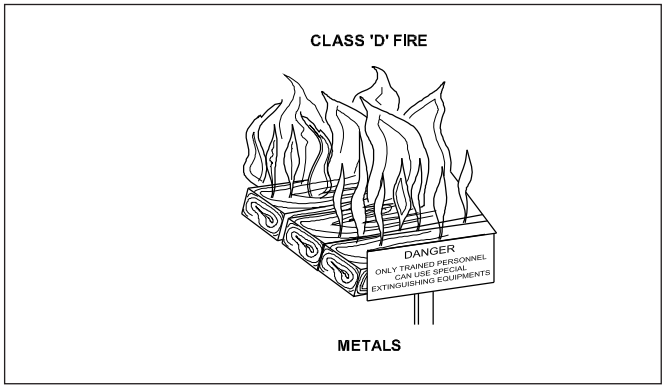
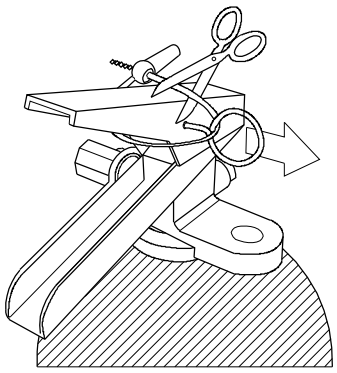
Class ‘A’: Wood, paper, cloth, solid material	
Class ‘B’: Oil-based fire (grease, gasoline,oil) and liquefiable solids	
Class ‘C’: Gas and liquefied gases	
Class ‘D’: Metals and electrical equipment	

7 Select CO2 (carbon dioxide) fire extinguisher.

8 Locate and take the CO2 fire extinguisher as in Fig 1b.

9 Break the seal. (Fig 2)

Fig 2

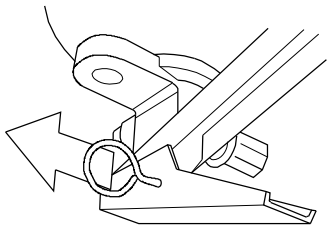


BREAK THE SEAL

PD20N212254H2

10 Pull the safety pin from the handle (the Pin is located at the top of the fire extinguisher.) (Fig 3)

Fig 3



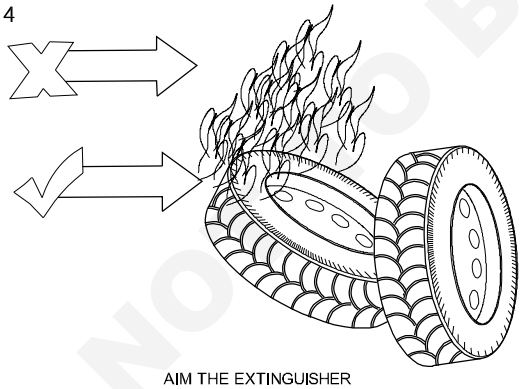
PULL THE SAFTY PIN

PD20N212254H3

11 Aim the extinguisher nozzle or hose at the base of the fire. (Fig 4)

Keep your self low.

Fig 4



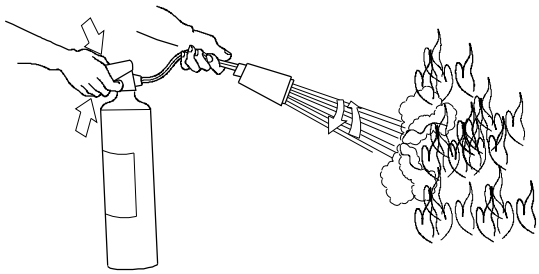
AIM THE EXTINGUISHER

PD20N212254H4

12 Slowly squeeze the handle lever to discharge the agent. (Fig 5)

13 Sweep from side to side approximately 15 cm over the fuel fire until the fire is put off.

Fig 5



SQUEEZE THE HANDLE LEVER

PD20N212254H5

Fire extinguishers are manufactured for use from a distance.

Caution

- While putting off fire, the fire may flare up.
- Do not panic so long as it is being put off promptly
- If the fire does not respond well even after you have used the fire extinguisher, move away from the fire point.
- Do not attempt to put out a fire when it emits toxic smoke. Leave it to the professionals.
- Remember that your life is more important than the property. So do not take risks.

In order to remember the simple operation of fire extinguisher, remember P.A.S.S.

This will help to use the fire extinguisher.

P for pull

A for aim

S for squeeze

S for sweep

TASK 2: **Procedure for wet chemical fire extinguisher**

1 With the large wet chemical extinguisher on the ground a safe distance from the fire, remove the safety pin and break the tamper seal.

2 Holding the lance at arm's length with the end hovering directly over the flames, aim the nozzle downwards onto the flames.

3 With the lever in your other hand, you then start to slowly squeeze this to discharge the wet chemical extinguisher, spraying it in slow circular motions.

4 Using the entire contents of the wet chemical fire extinguisher, make sure the fire is fully extinguished to cool down the area to prevent it from re-igniting.

— — — — —

TASK 3 : **Procedure for plain water extinguishers**

1 check that there is no live electrical equipment in the area

2 Pull the safety pin, this will break the tamper seal.

3 Squeeze the lever to start discharging the extinguisher.

4 Aiming the extinguisher nozzle:

- Fires spreading horizontally: Aim the nozzle at the base of the fire, moving the jet across the area of the fire
- Fire spreading vertically: Aim the nozzle at the base of the fire, slowly moving the jet upwards following the direction of the fire

5 As the fire starts to diminish carefully move closer to it

6 Ensure all the fire has been extinguished, try to focus on any hot spots that may re-ignite.

— — — — —

TASK 4 : **Procedure for dry powder extinguisher**

1 Pull the safety pin, this will break the tamper seal.

2 Squeeze the lever to start discharging the extinguisher.

3 Aiming the extinguisher.

- Solid Materials: Aim the nozzle at the base of the flames,moving across the area of the fire
- Spilled liquids: Aim the nozzle at the near edge of the fire and with a rapid sweeping motion, drive the fire towards the far edge until all the flames have been extinguished.
- Flowing liquid:Direct the nozzle at the base of the flames and sweep upwards until all the flames have been extinguished
- Burning gas: Switch off the gas supply as soon as you can! Aim the powder at the flare to extinguish

Electrical equipment: Switch off the power (if safe to do so) and then direct the nozzle straight at the fire Once the fire is extinguished, carefully scan for re-ignition, as this is possible when a powder fire extinguisher has been used.

Colour coding of Fire Extinguisher
Red – Water (both spray and mist)
Blue – Dry powder.
Cream – Foam.
Black – Carbon dioxide (CO2)
Yellow – Wet chemical.

— — — — —