

ANNEXURE - 1

(Rule 20 and 24) Electrical

Supervisor Examination

Syllabus for Examination of Electrical Supervisory Certificate of Competency- Electrical Supervisor (General Grade 2)

Paper - I

Electricity- Theory (Elementary Knowledge)

1. Principles of Electricity

Electric pressure, current and resistance – Ohm's Law, Kirchhoff's Law, specific resistance, laws of resistance and their application for calculating voltage drop-series and parallel circuit – simple problems. Practical units of voltage, current, resistance, power and energy. Relation between electrical power unit (kW) and mechanical power unit (HP). Inductance, capacitance, reactance and impedances. magnetic, chemical and heating effects of electric current.

2. Electromagnetism

Flux flux density – magnetic field strength, permeability – flux distribution due to straight conductor and circular loop – magnetic circuits – reluctance – calculation of MMF – effect of air gap – hysteresis loop of magnetic materials – force acting on a current carrying conductor – lifting power of a magnet.

Electro magnetic inductance – production of EMF – Flemings HandRules – Faraday's and Lenz's Law – statically and dynamically induced EMFs – self and mutual inductance – coupling coefficient. Magnetic properties of materials – electro magnets and their applications.

3. Materials

Conductors, non-conductors and insulators – insulating materials and their relative merits – transformer oil – effect of heat and moisture on insulation – lubricants and their uses – dielectrics – dielectric strength – permittivity.

Different types of wires, cables, switches, circuit breakers, fuses and their safe current carrying capacity. Use of tables and data sheets generally given in electrical hand book.

4. Generation of electricity

Methods of generation of electric power – Block schematic layout of generating stations – hydroelectric, thermal, nuclear stations. Non conventional energy sources – solar, tidal and wind power. Economics of generation – load factor, diversity factor, plant factor.

5. AC Generators (Alternators)

Basic principle – details of construction and essential components – voltage Rule – methods of voltage Rule – synchronous reactance, Rule, methods of voltage control and frequency control – synchronizing of alternators – conditions and methods for synchronising – synchrosopes – bright lamp and dark lamp methods – simple associated switch board and its accessories.

6. DC Generators

Basic principle – essential components – details of construction – shunt, series and compound generators and their characteristics – causes of sparking interpoles, commutators and their maintenance – carbon brushes – their adjustment and care – voltage Rule – parallel operation of DC generators – shunt, series and compound. simple switch board and its accessories.

7. Batteries

Primary cells, dry cells, storage or secondary batteries – lead acid and nickel cadmium batteries– construction–characteristics– charging and discharging. charging circuits and their calculation– series and parallel circuits – specification – maintenance – use of hydro meters.

8. AC Motors

Rotating magnetic field – three phase induction motors – construction – principle of operation – speed – frequency – slip – types – star delta starting. single phase induction motor - construction – different methods of starting. squirrel cage induction motor – slip ring induction motor – construction. Methods of starting – slip torque – slip characteristics – no load and blocked rotor tests – efficiency – circle diagram and determination of characteristics – synchronous motors – general principle of operation – uses – installation – methods of starting and speed control and reversal of direction – commutator motors. Torque calculation and basic knowledge of variable voltage and variable frequency drives (vvvfd).

9. DC Motors

Motor principle – series, shunt and compound wound type motors – their uses, installation – methods of starting – speed control – reversal of directions.

10. AC Circuits

Alternating current fundamentals – generation of alternating currents – waveform – frequency period – average value, rms value and form factor – different wave forms – phasor representation of alternating quantities – rectangular, polar and exponential forms.

Analysis of simple AC circuits with resistance, inductance and capacitance. Concept of impedance and admittance – phasor representation – ‘j’ notation. Power and power factor in ac circuits – active and reactive components. Solution of RL, RC and RLC circuits – series, parallel and series parallel circuits.

Three phase systems – star and Delta connection – relationship between phase and line values of voltage and current – phasor representation – solution of balanced and unbalanced three phase circuits – three wire and four wire systems – power in three phase systems – phase sequence – measurement of active and reactive power in single phase and three phase systems.

11. Switch gear and protection

Knowledge of various types of switches and protective fuses and circuit breakers like MCBs, ELCBs, ACBs, SF₆ breakers, etc, and cutouts, starters, regulators, protective devices for both AC and DC motors. Basic methods of transformer, generator, motor, and feeder protection. Thermal and magnetic releases – relays – IDMT, instantaneous type – over current, earth fault and earth leakage relays – time and current settings and their wiring with motors. Concepts, features and applications of static (electronic) relays, auto-reclosers, sectionalizers.

12. Transformers

Transformer – construction – use and maintenance – voltage and current relations – losses and efficiency – three phase transformer connections – star/star, delta/delta, star/delta, delta/star, V-V, T-T-Parallel operation of three phase transformers-Auto transformer – transformer tapings, temperature rise, automatic voltage boosters. Instrument transformers current transformers, potential transformers, ratio and phase angle errors, accuracy class (metering class, protection class etc.), polarity checking, CT and PT specifications.

13. Conversion

Principle of operation of motor – generator set, rotary or synchronous convertors, mercury-arc rectifiers, inverters, thyristors and other static devices. Battery chargers – voltage equation. Filtering – half wave – full wave and bridge rectifiers.

14. Transmission and Distribution

Bulk transmission of electric power – typical power transmission scheme – need for high transmission voltage. Sub-stations substation equipments – primary and secondary transmission and distribution systems – overhead lines – effect of power factor – general principles and simple problems. Line constants – determination of voltage drop – Rule. construction of lines of voltage upto 250 V and exceeding 250 V but not exceeding 33 kV, size of conductor, length of spans, sags, strength of poles, spacing of conductors, cross-arms, effects of temperature, wind pressure, ice and snow, tension of wire, insulators, brackets, stays, struts, guard wires, vibration dampers and other protective devices. Earthing – lightning arrestors and lightning conductors and their testing. Testing and fault location. Methods of working on overhead lines, equipment used for replacement of insulators, their ratings, methods of replacement of insulators, inspection of transmission and distribution lines. Concepts and advantages of 3-phase and 1-phase distribution systems of voltage exceeding 650 V but not exceeding 33 kV.

15. Underground cables

Simple calculations and general principles of laying Cables direct in the ground, in troughs and pipes, handling, bending, joining, plumbing, underground and above ground junction boxes. Distribution board and pillars. Joint box compound, melting of compounds and filling boxes with compounds. Testing and fault location – Murray Varley loop tests. Current rating – short time rating and continuous rating – derating factors of cables – basic knowledge of different types of cables – PVC, APVC, AYFY, XLPE – calculation of voltage drop.

16. Illumination and Street lights

Characteristics of different types of lamps – incandescent lamps, fluorescent lamps, vapour lamps – sodium and HPMV lamps – energy efficient lamps – luminous tube sign installations of voltage exceeding 650 V but not exceeding 33 kV. Photo metric units and simple measurements. General requirements of efficient lighting – simple problems on illumination. Street lighting-time switches. Different types of poles – swaged poles and step up poles. Different types of brackets – single upsweep, double upsweep, swan made type and 15° inclined with support. Lanterns – side entry/top entry lanterns, anodized parabolic reflector, POT reflector etc.

17. Electrical Safety Rules: Working knowledge of

- i. Wiring Rules
- ii. Protection and restoration of persons suffering from electric shock
- iii. Working on over head lines
- iv. Working in switch yard on voltage exceeding 650 V.
- v. Preliminary knowledge of Codes of Practices and Specifications prescribed by Bureau of Indian Standards.

Syllabus for Examination of Electrical Supervisory Certificate of Competency -
Electrical Supervisor (General) Grade 2

Paper - II

Electrical Energy Utilisation (Elementary Knowledge)

1. Design of electrical installations

a. Domestic Installations

Various systems of LT wiring – cleat, cable sheathed, wood casing and capping, metal sheathed, conduit and armoured cable for lighting and power in residential premises – types of wires and cables, standards sizes – estimates of material and cost of different types of installations – wiring of temporary installations together with necessary switchgear and portable appliances. Electrical wiring installations for large multi-storied residential buildings.

b. Industrial Installations

Load survey – connected load – maximum demand – demand factor – diversity load centre, selection of sub-station site – transformer capacity – selection of distribution voltage – main switch board – sub-switch board and distribution fuse board – MCC – PMCC – PCC – distribution layout – location of switch boards – fault level calculations – circuit diagrams.

2. Earthing

Resistivity of soil – measurement – computation of earth resistance – different materials used for earthing conductors – current densities – corrosion factors – determination of size of earth bus, number of earth electrodes – plate, pipe and strip electrodes – disposition of electrodes – joints in earth conductors – size of earth conductors for equipments of various capacities – earth continuity wire – earth continuity resistance – its Rules.

3. Selection of equipments

Different types of breakers – OCB – ACB – VCB – MCCB – MCB – contactors – breaking capacity – making capacity – selection of breakers – selection of switches – short time and continuous ratings – HRC fuses – uses – prospective currents – cut off values – selection of major and minor fuses – grading. Switch boards – design of outlets – fabrication – design parameters – FBARules. Cables – short time and continuous ratings – derating factors – design aspect of different types of cables. Hazardous areas. Motors – selection of starting methods of motors – DC motors – speed control – limitations on starting current and voltage drop – system disturbance. Motors of voltage exceeding 650 V but not exceeding 33 kV – protection – motor protection relays – capacitors – power factor improvement, selection. Methods of connection of Special type transformers – furnace transformers – welding transformers – rectifier transformers scott connection – tertiary windings. captive generation – determination of capacity – load segregation – double bus system – changeover arrangements – Indian Standards.

4. Energy measurements and tariffs

Measurement of Power – Wattmeters, Energy meters, Power factor correction by capacitors – Trivector Meters – Installation and Computation of energy – T.O.D meters. Tariffs – different types for LT and HT consumers – Simple calculations relating to cost of energy. – Concepts and features of electronic/digital metering

5. Installation, Testing and Maintenance

Insulation tester – earth tester – relay testing kit. Schering Bridge, Break down test of oil. Single phase and three phase energy meter testing, ammeter, voltmeter, wattmeter – different installation. Recommended values of insulation resistance – desired values. Polarisation index – earth resistance measurements – desired values. Polarity tests – test for earth continuity paths – rectification of faults. detection and location of faults in domestic appliances and wiring installations. Relay testing – maintenance of various electrical installations – relevant standards and Rules. Protective devices, basic knowledge of earthing of generators, motors, machines, installations and electrical appliances. Lightning protection – calculation of number of down conductors – test joint – lightning arrestors.

6. Cable Jointing

Aluminium and copper cable jointing – types – precautions – termination. Indian Standards.

7. Clearances

Statutory clearances of live parts from ground, buildings – sectional clearances – equipment clearances – clearance of switch boards – oil containing equipments – Indoor and outdoor equipment clearances.

8. Symbols.

List of symbols as per N.E.C – preparation of simple electrical wiring diagrams and electrical circuit diagrams – reading out simple electrical circuit diagrams.

9. Preparation of Schematic diagrams

Electrical connection for

1. DC and AC generators, switch board, transformers.
2. Main switch boards and sub-switch boards with circuit breakers, switch fuse units, with down stream load details in each circuit.
3. DC and AC motors, their starters, regulators.
4. Battery charging equipment.
5. Converting machinery.
6. Lifts with their safety devices.
7. X-ray.
8. Neon-sign.

10. Special Type of Equipments

X-ray, neon-sign, lift, cinema installations – relevant Rules – circuitry – safety precautions – earthing – fire precaution measures.

11. Energy Audit and Conservation-concepts and applications

12. SCADA systems and remote data acquisition and control general concepts and applications.

13. Rules and standards: Working knowledge of

1. Electricity Act, 2003.
2. Central Electricity Authority (Measures relating to safety and Electric supply) Regulations, 2010
3. Code of practice for Cinema and Lift and Escalators Installations.

ANNEXURE - 2

(Rule 24)

Syllabus for Examination of Electrical Supervisory Certificate of Competency -
Electrical Supervisor (Mines) Grade 2

PAPER - III

Mines Installations (Elementary Knowledge)

1. Wiring

Different types of wiring for power and lighting installations underground – different types of permissible types of cables to be used underground and in hazardous areas.

2. Preparation of schematic diagrams

1. DC and AC generators, switch boards, transformers etc.
2. Distribution boards with circuit breakers, switch fuse units with down stream load details in each circuit.
3. DC and AC motors with their starters and capacitors.
4. Battery charger and lamp cabin

3. Apparatus including flame proof apparatus for use in hazardous locations in coal and oil mines flame proof enclosures – general construction – rating plate and diagram of connections – rated voltage and frequency – rate outputs – rating of motors in flame proof enclosures – performance – temperature rise – tests for flame proofness.

4. Installation and maintenance of Electrical Equipments in Mines

1. General requirement of electrical equipment installed in mines – design – layout
2. Electrical protection of circuits and apparatus.
3. Protective measures against risk of electric shock.
4. Intrinsically safe apparatus and circuits.
5. Installation of electrical equipments.
6. Portable and transportable apparatus.
7. Cables.
8. Communication and signalling systems
9. Maintenance of electrical equipments in mines – Special precautions for maintenance of flame proof equipment – Special precautions for maintenance of intrinsically safe equipment
10. Installation and maintenance of:
 - a) Electrical winders, haulages and pump units, their control gears and starters.
 - b) Rectifiers, rotary converters and electric locomotives.

5. General principles and elementary knowledge of

1. Supply voltage for transmission, distribution and use underground
2. Control gear – transformers – insulated cables – cable terminal arrangement and sealing boxes – power distribution – motors and motor starters
3. Connected load – maximum demand – demand factor – diversity load centre

4. Power energy consumption in pumping, hauling and mining installations and other face machineries.
6. Power and energy measurement and tariffs

Measurement of power-watt meters – energy meters used in both DC and AC – power factor correction by capacitors – trivector meters – T.O.D. meters – their installation and computation of energy. Single and three phase static meters and principles of measuring energy consumption.

Tariffs – Different tariffs for LT and HT consumers – simple calculation relating to cost of energy.
7. Testing and fault attendance

Insulation tester – earth tester – relay testing kit – Schering Bridge, break down test of oil-single phase and three phase energy testing – voltmeter, ammeter and wattmeter testing – different installations – recommended values of insulation resistance – polarisation index – earth resistance measurements – desired values – Test for earth continuity paths – relay testing. detection and location of earth and faults in electrical apparatus and cables in voltage not exceeding 250 V and control circuits.
8. Flexing, trailing cables for portable and transportable apparatus. Knowledge of different types of cables including pliable armoured cables, their installation, maintenance, fault location, efficient repairs by vulcanized joints and testing.
9. Illumination, signaling and telecommunication system in Mines
10. Safety and protective devices
 1. Electrical protection of circuits and apparatus – protection against over currents – protection against earth leakage.
 2. Protective measures against risk of electrical shock – protection against contact with live parts – insulation resistance – protective earthing.
11. Safety Rules
 4. Working knowledge of Central Electricity Authority (Measures relating to safety and Electric Supply) Regulations, 2010, with particular reference to chapter X.

ANNEXURE - 3

(Rule 27)

Syllabus for Examination for Electrical Wiremen Permit Grade 2

1. Properties of copper and aluminium conductors. Properties of insulating materials such as PVC, XLPE, rubber and porcelain. Concept of voltage, current, power, energy, resistance, inductance, capacitance, impedance, power-factor. Simple calculation of current, power, energy and voltage drop. Comparison between series and parallel connection of loads.
2. Basic principle of bulk generation of electricity in hydel and thermal stations. Functions of sub-stations and transformer stations in power systems. Lead acid and dry type of storage batteries. constructional details, characteristics, charging and maintenance, tubular and maintenance free batteries.
3. Measuring devices. Principle of operation of voltmeter, ammeter, wattmeter, tong tester and multimeter. Measurement of energy in single phase and three phase circuits using energy meters. Checking of possible errors.

4. Transformers principle of operation, construction, KVA and current ratings – efficiency, care and maintenance. Induction motors. Principle of working of squirrel cage and slipring motors–starter, D.O.L., star/delta(semiautomatic and automatic) and rotor resistance types. Single phase motors principle. Different types of fan regulators –resistance and electronic types. Principle of operation of fractional horse power motors used in appliances such as mixies, washing machines, etc. Principle of operation of AC generators.
5. Various systems of LT wiring – types of wires and standard sizes – voltage and current ratings – thumbRules for voltage drop in cables. Main switch boards, sub switch boards and distribution boards – permissible loads – selection of location and standards clearances for main boards etc. Circuit breakers, MCCBs, switch fuse units, MCBs, etc standard ratings. Conduits – metallic and non metallic types – permissible numbers of wires in conduits. Wiring of Special equipments like UPS, invertors, standby for computers, etc. Essential factors for wiring high rise buildings.
6. Earthing of systems, necessity types of standards for earthing – selection of location – type and size of earthing conductors – minimum number of earth electrodes. Earthing of Special equipment.
7. Fuses, rewirable and HRC types – ratings, selection and grading. Circuit breakers – MCCB, MCB, Overload protection, Earth leakage protection – ELCB – principle of operation – standards leakage current ratings.
8. Principle of operation of invertors, UPS and electronic chokes, power ratings. principle of operation and characteristics of commonly used light sources such as incandescent lamps, fluorescent lamps, compact fluorescent lamps, vapour lamps.
9. Standard symbols of various types of electrical equipments – reading of schematic drawing for power and control circuits. Electrical workman tools and accessories.
10. Testing and commissioning of installations – standards, testing meters – insulation tester, earth tester, neon tester, hand held lamp tester. General knowledge of continuity and polarity tests in single phase and three phase wiring, insulation resistance and earth resistance test.
11. Safety measures to be observed while working – devices used for electrical workman safety. Knowledge on tariffs. Procedure for availing electric supply to consumer – submission of completion report. Energy efficient and trouble free maintenance of installations. Knowledge of energy conservation methods. Code of conduct and ethics to be observed by the electrical workman with the Contractor, consumer and the Regulatory Authorities. Protective measures against electrical shocks to working personnel, restoration of and first aid to persons sustaining electrical shocks.

ANNEXURE - 4

(Rule 12)

TESTING INSTRUMENTS, SAFETY TOOLS AND OTHER EQUIPMENTS REQUIRED TO BE KEPT AND MAINTAINED FOR OBTAINING ELECTRICAL CONTRACTOR'S LICENCES, SPECIAL WIRING PERMIT

a) For Super Grade: Testing Instruments

- 1) Insulation Tester
 - a) 5000V (b) 1000V (c) 500 V class each
- 2) Portable Voltmeter - range 0 to 600 volts.
- 3) Portable Ammeter – range 0 to 60 A.
- 4) Multi meter
- 5) Tong Tester