ELECTRICAL SAFETY
IN
ONSHORE PRODUCTION INSTALLATIONS IN E&P SECTOR

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Prepared by:
COMMITTEE ON
“ELECTRICAL SAFETY IN ONSHORE PRODUCTION
INSTALLATIONS IN E&P SECTOR”

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Preamble

Indian petroleum industry is the energy lifeline of the nation and its continuous performance is essential for sovereignty and prosperity of the country. As the industry essentially deals with inherently inflammable substances throughout its value chain – upstream, midstream and downstream – Safety is of paramount importance to this industry as only safe performance at all times can ensure optimum ROI of these national assets and resources including sustainability.

While statutory organizations were in place all along to oversee safety aspects of Indian petroleum industry, Oil Industry Safety Directorate (OISD) was set up in 1986 Ministry of Petroleum and Natural Gas, Government of India as a knowledge centre for formulation of constantly updated world-scale standards for design, layout and operation of various equipment, facility and activities involved in this industry. Moreover, OISD was also given responsibility of monitoring implementation status of these standards through safety audits.

In more than 25 years of its existence, OISD has developed a rigorous, multi-layer, iterative and participative process of development of standards – starting with research by in-house experts and iterating through seeking & validating inputs from all stake-holders – operators, designers, national level knowledge authorities and public at large – with a feedback loop of constant updation based on ground level experience obtained through audits, incident analysis and environment scanning.

The participative process followed in standard formulation has resulted in excellent level of compliance by the industry culminating in a safer environment in the industry. OISD – except in the Upstream Petroleum Sector – is still a regulatory (and not a statutory) body but that has not affected implementation of the OISD standards. It also goes to prove the old adage that self-regulation is the best regulation. The quality and relevance of OISD standards had been further endorsed by their adoption in various statutory rules of the land.

Petroleum industry in India is significantly globalized at present in terms of technology content requiring its operation to keep pace with the relevant world scale standards & practices. This matches the OISD philosophy of continuous improvement keeping pace with the global developments in its target environment. To this end, OISD keeps track of changes through participation as member in large number of International and national level Knowledge Organizations – both in the field of standard development and implementation & monitoring in addition to updation of internal knowledge base through continuous research and application surveillance, thereby ensuring that this OISD Standard, along with all other extant ones, remains relevant, updated and effective on a real time basis in the applicable areas.

Together we strive to achieve NIL incidents in the entire Hydrocarbon Value Chain. This, besides other issues, calls for total engagement from all levels of the stake holder organizations, which we, at OISD, fervently look forward to.

Jai Hind!

Executive Director
Oil Industry Safety Directorate
FOREWORD

The Oil Industry in India is over 100 years old. As such, various practices have been in vogue because of collaboration/association with different foreign companies and governments. Standardisation in design philosophies, operating and maintenance practices remained a grey area. This, coupled with feedback from some serious accidents that occurred in the past in India and abroad, emphasised the need for the industry to review the existing state-of-the-art in designing, operating and maintaining of oil and gas installations.

With this in view, the Ministry of Petroleum and Natural Gas in 1986 constituted a Safety Council, assisted by Oil Industry Safety Directorate (OISD) staffed from within the industry for formulating and implementing a series of self regulatory measures aimed at removing obsolescence, standardising and upgrading existing standards to ensure safer operations. Accordingly, OISD constituted a number of functional committees comprising of experts nominated from industry to draw up standards and guidelines on various subjects.

For some time, a need had been felt for a simple yet comprehensive document to provide basic information on electrical safety in areas related to onshore production installations in E&P sector. This document has been prepared keeping this objective in view.

This document will be reviewed periodically for improvement based on the field level experiences, incident analysis and better understanding. Suggestions from all stake holders are fervently solicited.
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These documents are intended only to supplement and not to replace the prevailing statutory requirements.
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“ELECTRICAL SAFETY IN ONSHORE PRODUCTION INSTALLATIONS IN E&P SECTOR”

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In addition to the above, various other experts from the industry contributed in the preparation, review and finalisation of this document.
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Electrical Safety in onshore production installations in E&P Sector

1.0 INTRODUCTION

Safety in Electrical System deserves maximum attention especially in the hydrocarbon industry, where electricity constitutes one of the major sources of ignition that could cause a fire or an explosion. Electrical hazards may cause injuries and fatalities to personnel due to electric shock and burn besides equipment damage and property loss. This standard is intended to serve as a consolidated guide to all those who are concerned with the design, inspection, operation, and maintenance of electrical system in onshore production installations.

The primary objective of preparing this standard is to ensure electrical safety in onshore production installations in E&P Sector.

2.0 SCOPE

This standard lays down the minimum safety requirements for design, inspection, operation, and maintenance of electrical equipment / systems on onshore production installations viz., GGS, OCS, GCS, CTF, GCP, WHI, QPS, EPS and ETP in Exploration and Production Sector.

OISD-STD-189 may be referred for definitions of aforesaid onshore production installations.

3.0 DEFINITIONS:

(1) Approved: Approved by the Chief Inspector (as defined in OMR, 1984) by a general or special order in writing and subject to such conditions as he may specify therein;

(2) Authorized person: a person authorized under CEA regulations;

(3) Circuit breaker: a device, capable of making and breaking the circuit under all conditions and unless otherwise specified, so designed as to break the current automatically under abnormal conditions;

(4) Cable tray: a horizontal or vertical metal/ non-metallic support for a cable run;

(5) CEA Regulations: Central Electricity Authority (Measures relating to safety and electric supply) Regulations, 2010 as amended from time to time;

(6) Earthed or Earth connection: A connection to the general mass of earth by means of an earth electrode. An object is said to be ‘earthed’ when it is electrically connected to an earth electrode; and a conductor is said to be ‘solidly earthed’ when it is electrically connected to earth electrode without a fuse, switch, circuit-breaker, resistance or impedance in the earth connection;

(7) Earth Electrode: A metal plate, pipe or other conductor embedded in the soil that makes a direct contact to the general mass of the earth;

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(8) **Electrical-in-charge**: a person in charge of the electrical department/section of the owner organization responsible for safe operation and maintenance of all electrical systems. He shall also ensure the system of issuing electrical permit as detailed in various sections, and conformity of installations with statutory requirements from time to time;

(9) **Earth Fault**: Accidental connection of a conductor to earth. When the impedance is negligible, the connection is called a dead earth-fault;

(10) **Earth Leakage Current**: The current flowing to earth on account of imperfect insulation;

(11) **Flammable material**: A flammable material is a gas, vapour, liquid, and/or mist which can react continuously with atmospheric oxygen and which may therefore, sustain a fire or explosion when such reaction is initiated by a suitable spark, flame or hot surface;

(12) **Flameproof Enclosure**: Type of protection in which the parts which can ignite an explosive atmosphere are placed in an enclosure which can withstand the pressure developed during an internal explosion of an explosive mixture and which prevents the transmission of the explosion to the explosive atmosphere surrounding the enclosure;

(13) **Flash Point**: The minimum temperature at which the liquid gives so much vapour that this vapour, when mixed with air, forms an ignitable mixture and gives a momentary flash on application of a small pilot flame under specified conditions of test;

(14) **Hazardous area**: An area shall be deemed to be a hazardous area, where
   (i) Petroleum having flash point below 65°C or any flammable gas or vapour in a concentration capable of ignition is likely to be present.
   (ii) Petroleum or any flammable liquid having flash point above 65°C is likely to be refined, blended, handled or stored at or above its flash point.

(15) **Hazardous Atmosphere**: An atmosphere containing any flammable gas or vapour in a concentration capable of ignition;

(16) **Ignition temperature**: The lowest temperature at which ignition occurs in a mixture of explosive gas and air when the method of testing ignition temperature specified in relevant Indian Standard is followed;

(17) **Intrinsically safe**: Type of protection based on the restriction of electrical energy within apparatus and of interconnecting wiring exposed to the potentially explosive atmosphere to a level incapable to cause ignition by either sparking or heating effects;

(18) **Degree of protection (IP code)**: The extent of protection provided by an enclosure against access to hazardous parts, against ingress of solid foreign objects and/or ingress of water and verified by standardized test;

(19) **OMR, 1984**: The Oil Mines Regulation, 1984 as amended from time to time;

(20) **Lightning Protection**: The whole system of interconnected conductors used to protect a structure from the effects of lightning;

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(21) **LOTO:** The placement of a lockout and tagout devices on an energy isolating device, in accordance with an established procedure, to ensure and indicate that the energy isolating device and the equipment being controlled cannot be operated until the lockout and tagout devices are removed.

(22) **Shall:** Indicates provisions that are mandatory;

(23) **Should:** Indicates provisions that are recommended but not mandatory;

(24) **Switchgear:** A general term covering switching devices and their combinations with associated control, measuring, protective and regulating equipment; also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures intended in principle for use in connection with generation, transmission, distribution and conversion of electrical energy;

(25) **Voltage, Low (LV):** The voltage which does not exceed 250 volts under normal conditions;

(26) **Voltage, Medium (MV):** The voltage which exceeds 250 Volts but does not exceed 650 volts under normal conditions;

(27) **Voltage, High (HV):** The voltage which exceeds 650 Volts but does not exceed 33,000 volts under normal conditions;

(28) **Voltage, Extra high (EHV):** The voltage exceeds 33,000 volts under normal conditions.

### 4.0 HAZARDOUS AREA CLASSIFICATION

#### 4.1 AREA CLASSIFICATION

**ZONE - 0**

An area in which a flammable atmosphere is continuously present. Examples are vapour space above closed process vessels, storage tanks or closed containers, areas containing open tanks of volatile, flammable liquids etc.

At any place within Zone-0 hazardous area no electrical equipment shall be used and where it is not practicable, intrinsically safe apparatus are only to be used with prior approval of the Inspector.

**ZONE-1**

An area in which a hazardous atmosphere is likely to occur under normal operating condition. The zone-1 area classification typically includes:

i) Imperfectly fitted peripheral seals of floating-roof tanks.

ii) Inadequately ventilated pump rooms for volatile, flammable liquids.

iii) Interiors of Sample Retention Room/ Cabinet as part of quality control laboratories, refrigerators and freezers in which volatile flammable materials are stored in lightly Stoppard or easily breakable containers.

iv) Area below ground level of flowing/ artificially lifted wells

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v) Areas in the immediate vicinity of gas vents

vi) Trench/pit below ground level

ZONE-2

An area in which a hazardous atmosphere is likely to occur only under abnormal operating conditions. The zone-2 area classification typically includes:

- Area surrounding Oil-Gas separation vessel, Dehydrator, Hydrocarbon recovery unit
- Pump handling flammable liquid
- Gas compressor
- Relief valve

For further details, DGMS letter No. 1 (6) 2001- Genl / 3604 -3753 dated 12th Sept, 2001 for “Classification of hazardous area in Oil mines under Regulation 74 of the Oil Mines Regulations, 1984” or latest DGMS circular/notification should be referred.

4.2 AGENCY CERTIFICATION

Approval from DGMS shall be available for equipment used in hazardous area

5.0 ELECTRICAL SYSTEM REQUIREMENTS

The design of electrical installation shall ensure provision of a safe and reliable supply of electricity at all times. Safe conditions shall be ensured under all operating conditions including those associated with start-up and shut down of plant, as well as those arising out of failure of electrical equipment. Power distribution system shall constitute sub-stations located near load centres as far as practical. Special attention should be drawn to Chapter IX of CEA (Measures relating to safety and electric supply) regulations 2010 which includes requirements for electrical system as applicable to oil mines and oil fields.

5.1 EARTHING SYSTEM

Earthing system design shall be carried out in accordance with the requirements of CEA regulations 2010 and IS:3043.

5.1.1 PLANT EARTHING

i) Earthing system in general, shall cover the following:

- Equipment earthing for personnel safety,
- System neutral earthing, and
- Static and lightning protection.

ii) The earthing system envisages an earthing network with designed number of earth electrodes attached to it. The following shall be earthed:

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Metallic non-current carrying parts of all electrical apparatus such as transformers, switchgears, motors, lighting/power panels, terminal boxes, control stations, lighting fixtures, receptacles etc.

Current and potential transformer secondary neutral

System Neutral

Steel structures, Loading platform etc.

Metallic Cable trays and racks, lighting mast and poles.

Storage tanks, spheres, vessels, columns and all other process equipment.

Electrical equipment fencing (e.g. transformer, yard etc.)

Cable shields and armour

Flexible earth provision for Tank Wagon, Tank Truck

iii) Lightning protection shall be provided for the equipment, structures and buildings as per the risk index analysis worked out as per IS 2309.

iv) The maximum resistance value of an earthing system to the general mass of earth should not exceed:
   - 4 ohms for electrical systems and metallic structures.
   - 7 ohms for storage tanks.
   - 1 Ohm for main earth grid

v) Earth leakage protection of sensitivity 30mA shall be provided in office lighting and power point socket circuits to ensure personal safety.

vi) All joints in pipelines, valves, plants, storage tanks, cable tray and associated facilities and equipment for petroleum shall be made electrically continuous by bonding or otherwise; the resistance value between each joint shall not exceed 1 Ohm.

**Minimum Size of earthing conductors for electrical equipment is given as Annexure-B.**

### 5.1.2 NEUTRAL EARTHING

**NOTE-1**

i) Power system neutral shall be earthed:
   a) To limit the difference of electric potential between all uninsulated conducting objects in a local area.
   b) To provide for isolation of faulty equipment and circuits when a fault occurs.
   c) To limit over voltages appearing on the system under various conditions.

ii) The neutral earthing resistor shall be able to carry at least 10% of its rated current continuously, unless otherwise required, and full rated current (100%) for a minimum duration of 10 seconds.

Note-1: In oil mines & oil fields, earth fault currents shall be limited to not more than 750 mA in installations of voltages exceeding 250 V and up to 1000 V. (Rule 100 of CEA regulations 2010).
5.2 PROTECTION AND METERING

i) The protective system shall be selected and coordinated to ensure the following:

a. Protection of equipment against damage which can occur due to internal or external short circuits, overloading, abnormal operating conditions, switching, lightning surges, etc.

b. The continuity of operation is maintained to those parts of the system not affected by the fault.

c. Personnel and plant safety.

Accordingly, relays and protective devices shall be suitably selected and coordinated.

ii) Recommended relay protections for Transformers, motors and feeders which are generally encountered in distributing network are given in Table-I (Relay protection system) of OISD STD -149.

5.3 EMERGENCY POWER SUPPLY

i) An independent back-up source of adequate capacity of electric energy if required that upon failure or outage of normal source, automatically provides reliable electric power within specified time to critical devices and equipment whose failure to operate satisfactorily may jeopardize the health and safety of personnel or result in damage to property.

ii) The emergency power supply system shall feed the following loads to enable continuity of supply in the event of failure of Main Supply.

- Electrical loads essential for the safe shutdown of the plant.
- Emergency lighting, security lighting, obstruction lights.
- Process plant instruments as required.
- Communication equipment, Fire Alarm control panels.
- Fire fighting equipment excluding main fire water pumps.
- Loads critical for process, plant and personnel safety.

iii) Emergency power supply shall be available as per process/equipment requirements, but within a period not exceeding 30 seconds from the instant of failure of normal supply.

5.4 CRITICAL POWER SUPPLY SYSTEMS

These systems shall have inherent independent battery backup to maintain continuity of supply to critical loads (e.g. process control, communication, fire alarm systems etc.) in the event of Normal/ Emergency supply failure – UPS or DC Power Supply.

Following loads should be connected to the critical power supply system:

- Critical Lighting system
- Critical instrumentation and process control,
- Critical communication equipment,
- Fire and Gas detection system

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5.5 SUBSTATION LOCATION / LAYOUT

i) The sub-station should be located in a safe area. OISD Standard 118 ‘Layout for Oil and Gas Installations’ to be referred.

ii) The switchgear layout shall allow sufficient space at front of the switchgear to withdraw and maneuver the circuit breaker trolley and at the rear to allow access for cable terminations, maintenance and inspection of equipment. CEA regulations 2010 to be referred for minimum clearance between various equipment.

iii) Cable trenches, wherever provided, inside sub-stations shall be filled with sand, pebbles or similar non-flammable materials or covered with incombustible slabs except where cables are laid on cable trays in a concrete trenches. All cable entries to the sub-station building should be properly sealed to prevent entry of any fluids/chemicals etc.

iv) Fire extinguishers, suitable for electrical fires (CO_2 type) and round bottom fire buckets with clean dry sand, conspicuously marked, should be kept in easily accessible position near the switchgear enclosure.

v) The switchgear rooms should be kept clean and tidy and should not be used as a storage room, especially for combustible materials such as discarded printer outputs, newspapers, cans, rags for cleaning etc.

vi) Each substation building shall have at least two doors. These exits shall be located at opposite ends of the building, to prevent the possibility of operating personnel being trapped. The doors shall open outward.

vii) It is recommended to locate DG sets in a separate house/shed away from Substation in a safe area to reduce noise level in substation. If required DG set of smaller rating can be located in substation building provided the substation is located in a safe area. However in such cases, the foundation of such D.G. sets shall be structurally delimited from the slab or floor of the rest of the substation building. Exhaust of Diesel Engine shall be kept away from Process/Hydrocarbon area.

The day tank for diesel shall not be located inside the emergency DG room as it is a potential source of fire and may also release flammable vapours. The day tank shall be located outside the DG room within a fenced area, preferably with a corrugated sheet roof to provide protection from direct sun and rain.

viii) The building shall be sized to take care of present/future needs and to maintain adequate clearances between equipment, and equipment and wall for ease of operation and maintenance.

ix) Normally transformers, reactors, neutral earthing resistors shall be installed outdoor.

x) The battery room shall be a separate and freely ventilated room in the sub-station building/ control room alongwith the necessary exhaust system and water connection. Floor of the battery room and the walls upto height of one metre shall have acid resisting material/coating/be painted with acid/alkali resistive paint or otherwise protected. The battery room door (usually opposite to the fan location) should be fitted with louvers at the bottom to ensure cross ventilation. All electrical switches shall be kept outside so that there is no possibility of arc or spark in battery room. All electrical fittings shall be vapour tight/ flame proof, thereby precluding the possibility of ingress of hazardous gases into the fixtures.

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5.6 ELECTRICAL EQUIPMENT

Electrical equipment shall be selected, sized and installed so as to ensure adequacy of performance, safety. The equipment in general shall conform to relevant Indian Standards and shall be suitable for installation and satisfactory operation in the service conditions envisaged.

Certain essential safety features in design to be considered in specifying and sizing of commonly encountered equipment such as Transformer, Switchgear, Motors, Cables, are enumerated below. For detailed design aspects provisions given in Oil Mining Regulations (OMR) and DGMS circulars shall be followed.

A. TRANSFORMERS

i) Transformers shall be provided with accessories and protective devices as per IS 2026/IEC 76. The rating and the percentage impedance of transformer shall be compatible to permit start of highest rated motor while the transformer is preloaded with maximum operating base Load. Transformers of rating 2000 KVA and above should preferably have winding temperature indicators with alarm / trip provisions.

B. HIGH VOLTAGE (H.V) /MEDIUM VOLTAGE (M.V) SWITCHBOARDS

i) These shall be designed to ensure maximum safety during operation, inspection, connection of cables and maintenance with Switchboards energised.

ii) The switchboard shall be totally enclosed, dust and vermin proof.

iii) Barriers shall be provided to permit personnel to work safely within an empty compartment with the bus bars energised. The minimum clearance and creepage distance of bus bars shall conform to relevant IS/IEC standards.

i) The drawout carriage on the switchboard shall have three positions viz., ‘Service’, ‘Test’ and ‘drawn out’. Automatic safety shutters shall be provided to ensure the inaccessibility of all live parts after the breaker is drawn out. There shall be distinct overall door for the breaker compartment and it should be lockable.

Suitable interlocks shall be provided (wherever applicable) to prevent faulty operation such as:
- ‘Plugging in’ or ‘drawing out’ of a closed breaker.
- ‘Plugging in’ a breaker with earthing isolator closed.
- ‘Closing’ of earthing isolator with the breaker ‘Plugged in’.
- Pulling out of auxiliary circuit plug with breaker in service position.
- Pushing in breaker to service position with auxiliary circuit plug not in position.
- Opening of compartment door with isolating switch in ON position and vice-versa for switchboards.
- It shall not be possible to operate the circuit-breaker unless it is fully in service or Test or isolated position.

v) Busbars and supports shall withstand specified short circuit level without permanent deformation. Busbars shall be preferably sleeved and joints shall be taped/shrouded. Feeder tag plates shall be provided at both front and rear side of panels. Busbar arrangement shall be clearly marked on the back side of the switchboard Bus-coupler panel for easy identification during maintenance.

vi) All non-current carrying metal parts of switchgear and control panels shall be properly earthed. Insulating mats of appropriate voltage level (conforming to IS-15652) shall be

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provided in front and rear side of the panels for the safety of operating personnel.

vii) All panels shall be painted with the description of its identification at front and at the rear.

viii) Starting of motors from substation shall not be allowed and switch boards shall not have close push button at switchboard for motor starting.

ix) Switch Boards shall have anti condensation heaters.

x) All H.V. switchgears should have provision of view glasses/ IR windows to take thermographic readings for predictive / preventive maintenance. It must be ensured that all such switchgears with view glasses windows have been duly type tested and certified for internal arc faults as per the provisions envisaged in IEC:62271 or other equivalent international standard.

C. MOTORS HIGH VOLTAGE (H.V.) & MEDIUM VOLTAGE (M.V)

i) The minimum degree of enclosure protection for motor should preferably be IP 44 for indoor use and IP 55 for outdoor duty motors. All H.V. motors shall have anti condensation heaters.

ii) The permissible noise level shall not exceed the stipulations laid down in as per Central Pollution Control Board (CPCB) guidelines.

iii) For HV motor, as a minimum, winding insulation shall be class F and temperature rise limited to that specified in the applicable IS for class B insulation

D. EMERGENCY GENERATOR

i) Emergency generator shall be designed to start automatically on power failure and feed the selected loads.

ii) Diesel Engine installation, do not call for Area Classification, provided the D.G. room is properly ventilated. Normally the ventilation provided to remove heat from the radiator is adequate to take care of hazard aspect. DG sets shall comply with the latest guidelines of environment ministry with regard to noise levels.

iii) OISD STD 127 to be referred for details on operation, inspection & maintenance of Diesel Engines.

E. CONTROL STATION

i) Each Motor shall be provided with a control station in the field. In case of PLC operated motors, a STOP push button as a minimum shall be provided in the field. Motors installed at elevated platforms (such as cooling tower fan, air fin cooler etc.) shall be provided with one emergency stop push button at ground level in addition to one near motor.

ii) The control station enclosure shall have suitable protection as per hazardous area classification.

iii) The control station shall include the following equipment as per individual process requirements:

   - Start/stop push button/close, neutral, Trip Switch
   - Ammeter,

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iv) Stop push button shall have stay put feature except in the case of critical drives such as lube oil pump etc.

5.7 PLANT CABLING

i) Cables below ground may be laid in concrete trench/tunnel or directly buried. Cables above ground shall be laid in cable trays/cable racks.

ii) Cabling for fire water system shall as far as possible be taken in exclusive route through underground trench.

iii) Cable trenches in hazardous area shall be filled with sand and covered with RCC slabs to prevent accumulation of flammable gas/vapour inside the trench.

iv) Cable trays should not be installed at an elevation where acid/hydro-carbon piping is located above the cable tray.

v) No welding or naked flame should be allowed inside cable tunnels and cellars. Same, if unavoidable, shall be carried out with proper work permit and precautions meeting norms under OISD-STD-105.

vi) Cables used in hazardous area shall be DGMS approved.

5.8 PLANT LIGHTING

i) In addition to the normal lighting, each installation shall be equipped with emergency and critical lighting.

ii) Emergency lighting shall enable the operators to carry out safe shut-down of the plant, to gain access and permit ready identification of fire fighting facilities such as fire water pumps, fire alarm stations etc.

iii) Critical lighting shall enable safe evacuation of operating personnel and shall be employed along escape route, assembly point and critical installations such as first aid centre, control rooms, manned sub-stations, fire water pump house etc.

iv) For hazardous areas, emergency lighting fixtures shall be explosion proof Ex(d) type, irrespective of the area being classified as zone-1 or zone-2.

v) The illumination levels in different areas shall be as per good engineering practice. Depending on the nature of job activities to be carried out the suggested minimum illumination levels for various areas are given in OISD STD 149.

vi) On the surface of a mine or in an open cast mine, the voltage may be raised to 250V, if the neutral or the midpoint of the system is connected with earth and the voltage between the phases does not exceed 250V.
6.0 INSTALLATIONS

Procedure for installation of electrical equipment at new site or in existing operating plant should be prepared covering following minimum aspects, for each equipment type:

1) Material handling
2) Personal Safety
3) Equipment manufacturer recommendation
4) Pre-commissioning and commissioning procedures
5) Authorised personal
6) Communication protocol

OISD-GDN-192 and OISD-STD-147 for safety practices during construction and installation should be referred for further details. Provisions given in Oil Mining Regulations (OMR) and DGMS circulars shall be followed to ensure safety during installation.

7.0 PRE-COMMISSIONING CHECKS

Before commissioning electrical equipment after repairs and maintenance, the following minimum pre-commissioning checks are recommended for reference. Wherever manufacturer's recommendations are available, the same shall prevail.

In the case of newly installed facilities also, the same pre-commissioning checks shall be applicable but additionally the following shall be ensured:

i) The statutory clearances from the State Electrical Inspectorate/Director General, Mines Safety, (as the case may be) shall be obtained for the schemes and installations.

ii) Manufacturer’s test certificates shall be obtained (for the successful passing of shop tests.

iii) Installations conform to acceptable engineering standards and are appropriate to the respective hazardous area classifications. Installations with all individual Isolating devices (for safe disconnection of electrical circuits) shall be easily accessible for regular and emergency operation and maintenance.

Check list with some of the safety aspects for select items are provided below. The same should be developed in similar lines for other equipment.

7.1 GENERATOR

Following checks should be carried out:

1. Check Name plate details.
2. External body of the Generator for any damage
3. Condition of terminal box: tightness of nuts & bolts, missing bolts, condition of bushings.
4. Cable connections
5. Adequate support to cable with tray/ clamp etc.
6. Foundation bolts – Tightness

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7. Check terminal bushings for any damage or looseness
8. Check for any blockage of ventilator openings
9. Checking of exciter/field/stator coils, AVR, Rectifier Bridge, brushes, surge suppressor or variable resistor (varistor) etc.
10. Checking of Engine Control Switches viz. LLOP, HWT, etc.
11. Checking of Annunciator Circuits
13. Proper functioning of Space Heaters.
14. Terminal Box : Open up the Terminal Box and check following
   • The studs – No. of Studs, Nut/bolts and washers provided or not.
   • Terminals ends are numbered or not,
   • Tightness of the Terminations.
15. Condition of bearings
16. Oil lubrication (adequacy & Oil quality)
17. Earthing connections (body & neutral)
18. Protection circuits (testing and simulation tests)
19. Auto/manual starting and changeover system
20. Earthing connection: check
   • Check for proper earthing materials and done with proper practice.
   • Tightness of earthing studs.
   • Socket/ lugs, if earthing is done with stranded bare /insulated conductor.
   • Physical connection to dedicated earth electrodes.
21. Measure and record Insulation Resistance value with the help of an insulation tester
   • Between Phase to Phase
   • Phase to Earth
   • Neutral to earth (neutral disconnected)
22. Measure & record PI (polarization Index) value. It should be greater than 2.
23. Continuity check for windings.
24. Ensure that the winding resistance values are equal in all the phases.
25. Earth resistance value (ensure that it is within recommended value)
27. Whether the enclosure provides ease of maintenance.
28. Adequate shed with rain protector provided.
29. Whether earth pit no: earth resistance value & test date have been written on the earth pit cover or by any convenient means.
30. Whether Location/ position of earth pit maintainable.
31. The gen sets should have nomenclature such as G1, G2, Set -1, Set 2 etc. for ease of identification.
32. In case of Acoustic Enclosure
   Check the following:
   a. Measure the noise level to ensure that it is as per CPCB norms. (Max 70db within 1 metre as per CPCB norms)
   b. Adequacy of Illumination inside the enclosure
   c. Functionality of Gas Detector.
   d. Functionality of Emergency Shut Down Switch
   e. Functionality of Blower fans
   f. Remove any oil spillage.
33. Alternator Control panel
   The followings shall be checked:
   a. Check for any damage.
   b. Check and tight Foundation Bolts.
   c. Check for proper cabling and termination.

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d. Check whether appropriate cable lugs/sockets are used.
e. Earthing connections.
f. Checking and testing of protection scheme and relays
g. Check set values of protective component/equipment

34. After Generator is started, check following
   a. Voltage building up at all the phases.
b. Excitation voltage.
c. Excitation current.
d. Healthiness of protection circuit
e. Healthiness of measuring instruments.
f. Healthiness of indicating lamps.
g. Emergency push button operation
h. Battery charger circuit.
i. Space heaters, if provided.
j. Load on the generator
k. Overheating of alternator/exciter/bearings
l. Speed whether steady or hunting (growling)
m. Audio visual annunciation
n. Synchronization panel:
   • Functionality of the Synchroscope.
   • Healthiness of indicating lamps
   • Healthiness of switches

35. Electrical checks/testing as recommended by OEM.

7.2 ELECTRIC MOTOR

Following checks should be carried out:

1. Check name plate details
2. External body of the motor for any damage
4. Cable termination (check also for proper size and type of cable)
5. Driving end condition:
   • Intactness of grease nipple
   • Intactness of coupling protective cover
6. Non-driving end condition:
   • Intactness of grease nipple.
   • Condition of cooling fan
   • Condition of cooling fan cover
   • Condition of fixing bolts/studs
7. Foundation bolts -Tightness
8. Freeness of Rotor shaft.
9. Cleanliness (free from dirt, dust and moisture)
10. Open up the Terminal Box and check:
    • The studs – No. of Studs, Adequate Nut/bolts and washers
    • Terminals ends are numbered or not
    • Tightness of the Terminations.
11. Physical connection to dedicated earthing Grid.
13. Measure and record Insulation Resistance value with the help of an insulation tester
    • Between Phase to Phase,
    • Phase to Earth

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14. The continuity check for windings.
15. Ensure that the winding resistance values are equal in all the phases.
16. Insulation resistance (before and after connection of the power cables)
17. Connection and operation of space heater where provided. (ensure its automatic
switching off when motor is started and switching on when motor is stopped),
18. Connection/ Termination of cables as per drawing – at Power source, starter, motor.
19. Earth resistance value (ensure that it is within recommended value)
20. Ratings of control and power fuses.
21. Ensure protection relays are set as per recommended relay settings
22. Functional checks of motor control and protective circuits with interlocks and all
audio visual annunciation.
23. Start the motor on no-load and check following
   a. Motor parameters
      • Supply voltage and frequency
      • Direction of rotation.
      • Abnormal sound
      • Temperature rise
      • Vibration
      • No load current
      • Speed
   b. Healthiness of cooling system.
24. Electrical checks/ testing as recommended by OEM.

7.3 ELECTRICAL PANELS

The followings checks should be carried out:

1. Check for any damage.
2. Tightness of foundation bolts.
3. Cleanliness (free from dirt, dust, moisture etc.)
4. Remove covers of enclosure and cable boxes of all incoming and outgoing, busbar
   and check for any foreign object. Check support insulators, phase barriers for any damage.
5. Check for proper cabling and termination.
6. Vermin proofness (whether unused openings closed)
7. Functionality check/ testing of CBs, MCCBs, CT, PT, Bus Bar, protection relays,
   Energy meters, Power Packs etc.
9. Insulation resistance measurement for Bus Bar, power cables, Breakers.
10. Switchgear panel earthing by two separate and distinct connections to earth.
11. Primary injection testing of switchgear Incoming and Outgoing panels.
12. Secondary injection testing of protection relays
13. Loop checking of field and instrument cables.
14. Testing of differential protection schemes (Bus bar, feeder, motor)
15. Electrical & manual closing and tripping of all circuit breakers (remote and local)
16. Check Circuit Breakers for proper racking-in and rack-out operation.
17. Healthiness of space heaters, if provided.
18. Healthiness of Indication Lamps & panel meters.
19. Availability of Insulating mats, updated Single line diagram.
20. Healthiness of panel space heaters.
21. Electrical checks/ testing as recommended by OEM.

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7.4 TRANSFORMER AND BUS-DUCT

Following checks should be carried out:

1. Check name plate details.
2. Provision of all the accessories
3. External damages (especially on bushings)
4. Body and neutral earthing/earth resistance
5. Check foundation bolts tightness
6. Check insulation resistance and PI of HV and LV windings.
7. Check winding resistance values.
8. Dielectric strength of Transformer oil (as per IS: 335)
9. Oil level in the conservator, bushings and thermometer pockets
10. Operation of the tap changer circuits on all the tap positions (simulation)
11. Check for any leakage of oil
12. Check the healthiness of silica gel in breather
13. Functioning of Buchholz relay
14. Check phase sequence and connections for vector group.
15. Neutral grounding resistor especially for earthing connection and earth resistance.
17. Checking/ testing of marshalling panel
18. Oil/ winding alarm/ trip ckt. simulation. Protection system checking.
19. Cooling system (automatic starting and stopping of fans)
20. Sealing of busduct entries through walls (for vapour, dust, water tightness)
21. Vermin & dust proofness and earth connections of bus ducts
22. Busduct supports
23. Expansion joints and flexible connection of bus duct.
24. After Transformer is energized, check following
   a. Oil leakage, if any
   b. Proper circulation of transformer oil
   c. No-load current is within limit.
   d. Transformer hum or abnormal noise, if any
   e. Phase sequence checking (parallel operation)
25. Electrical checks/ testing as recommended by OEM.
26. Radiator valve are in open position
27. Air release by opening all vent plugs

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8.0 OPERATION AND MAINTENANCE

8.1 GENERAL

No person shall carry out any maintenance, repairs, alterations or testing on electrical equipment unless the equipment is electrically isolated from all possible source of supply.

8.2 RESPONSIBILITIES OF ELECTRICAL INCHARGE

Electrical Incharge shall define the responsibilities for operating and maintaining electrical systems so that the personnel are aware of the scope and limits of their operational responsibilities.

8.3 COMPETENCY PROGRAMME AND AUTHORISATION

No persons shall be allowed to carry out operations, work or testing on any part of the electrical system unless they meet the required competency and are authorised to perform the task.

Competency requirements, training, validation and authorisation methodology should be prepared.

8.4 ELECTRICAL PERSONAL PROTECTIVE EQUIPMENT (PPE)

Appropriate PPE for the task shall be used by persons working on or near live electrical equipment to protect them from shock and/or arc flash hazards.

List of PPEs for E&P production installations are given as Annexure- A

8.5 USE OF PORTABLE/TRANSPORTABLE ELECTRICAL EQUIPMENT

8.5.1 GENERAL

All portable and transportable electrical equipment shall be of approved type. Prior to each use, the users shall inspect and verify that the portable and transportable electrical equipment is in good condition and approved for the use in the environment in which it is to be used.

8.5.2 PORTABLE (HAND-HELD) ELECTRICAL EQUIPMENT

Portable electrical equipment used in hazardous (classified) areas shall be suitably certified for that area, or authorised for use by gas testing.

8.5.3 MOBILE GENERATORS FOR TEMPORARY USE

All mobile generators for temporary use shall be inspected prior to their use to prevent unsafe situations.

8.5.4 EXCAVATION

Establish procedure to identify underground services and power cables and the necessary safety precautions to be used during excavation.

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8.6 WORK PERMIT SYSTEM:
Work Permit System shall be followed as per OISD STD 105 on “Work Permit System”. Detailing in respect of de-energisation and energisation shall also be available in the shift logbook. Log Sheet format for mines and oil fields is given in Format-I. Electrical Isolation / energisation permit format of OISD-STD-105 is given in Format-II. Alternatively, electrical isolation/ energisation permit format of IS:5216 can be used provided it is interfaced with Hot/ Cold work permit of OISD-STD-105.

Since several maintenance/ construction jobs are often carried out with assistance from contractors, it is essential to provide sufficient exposure to contractor and his employees as well on the work permit system.

It is recommended to implement LOTO (lockout and tagout) in electrical work permit system to prevent inadvertent operation due to wrong communication, poor job knowledge or human error. Lock out device (e.g. Pad Lock) will physically prevents accidental energisation of a machine / electrical equipment. Tag out device will provides information about the nature of the lock out, and warns working personnel not to operate the particular machine/ electrical equipment.

8.7 FIRE FIGHTING FACILITIES:
Firefighting facilities shall be provided as per OISD-STD-189 on “Fire fighting equipment for drilling rigs, work over rigs and production installations”.

8.8 INSPECTION OF ELECTRICAL EQUIPMENT
All transformers, batteries, stationary & rotating electric equipment etc. including portable/ hand held electrical apparatus shall be inspected as specified in OISD-STD-137 on “Inspection of electrical equipment” and records maintained thereof.

8.9 ISOLATION/ ENERGISATION OF ELECTRICAL EQUIPMENT
Energisation and De-energisation procedures shall be developed covering following minimum aspects -

• Sequence of operation
• Isolation and earthing locations
• Specific equipment numbers
• Responsibilities

8.10 MINIMISING EQUIPMENT FAILURE
1. Proper functioning of electrical equipment can only be ensured by means of periodic preventive and predictive maintenance of the equipment. This enhances equipment life and also ensures safety of the equipment, installation and operating personnel.
2. Maintenance may be daily, weekly, quarterly or annual depending upon the type of equipment. Adequate logs shall be maintained to ensure that maintenance is carried out as per approved checklists. Preventive maintenance should be carried out as per schedules laid down in OISD STD-137.
3. Live parts of switch gear shall be made inaccessible from any inadvertent physical contact, lizard entry etc. These shall be suitably covered by barriers and shrouds.
4. It shall be ensured that the electrical installation shall be rust / corrosion protected. This should be achieved by painting all equipment at regular intervals by use of zinc passivated, nickel plated hardware, stainless steel hardware, through provision of canopies for outdoor equipment and covering of terminal boxes to prevent ingress of water etc. Battery rooms

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shall be kept dry and well ventilated and all terminals shall be kept covered with petroleum jelly to avoid corrosion.

5. During maintenance if any equipment is removed from panel doors, etc. which leaves an open cutout on the equipment, the same shall be promptly sealed using blanking plates or other means, to ensure that there is no loss of the degree of ingress protection and also that this does not provide a means of access for entry of dust / vermin etc. It shall be ensured that all unused cable entries are blanked off.

6. All battery banks shall be routinely checked for healthy cell voltage, specific gravity of cells, electrolyte level etc.

7. Insulation resistance of all electrical equipment, such as, all switchboards, motors, transformers, cables etc. shall be routinely measured and logged to ensure healthiness of equipment.

8. Dielectric strength of transformer insulating oil, Oil Circuit Breakers etc. shall be measured at regular intervals and recorded and oil filtration shall be carried out wherever necessary. Dissolved Gas analysis for transformers rated 5MVA and above may be carried out as a predictive method to assess health of transformer.

9. All cable terminations, bus-bar joints, etc. shall be tightened, more so for equipment subjected to vibrations, to ensure that there are no hot spots which could lead to fire / equipment failure.

10. Settings of protective relays shall be checked to ensure that they are set as per the recommended settings. Protective Relays shall be tested / calibrated once a year to ensure proper operation as per manufacturer's recommendations.

11. Unused cable entries in any switchboard / Electrical installation shall not be kept open.

12. Conduits used for cable entry shall be sealed and earthed.

13. All wall openings of an electrical substation including cable entries shall be properly sealed to arrest water entry inside substation.

14. Transformer and switchyards shall be maintained free of vegetation / dry grass.

15. Earth grid resistance shall be measured and recorded regularly to ensure operation of related protective devices in case of fault.

16. All electric apparatus and wiring in a hazardous area shall at all times be so maintained as to retain the characteristic on which their approval has been granted.

17. Equipment enclosures and fittings shall be examined to see that all stopping plugs and bolts are in position and properly tightened. Locking and sealing devices shall be checked to ensure that they are secured in prescribed manner.

18. Replacement fasteners, nuts, studs and bolts shall be of the type specified by the manufacturer for the particular apparatus. No attempt shall be made to replace or repair a glass in a flameproof enclosure e.g. in a luminaire or other enclosures, except by replacement with the complete assembly or part obtainable from the manufacturer, complying with the approval certificate.

19. If at any time, there is a change in the area classification or in the characteristics of the flammable material handled in the area or if the equipment is relocated in the area, the area classification drawing should be correspondingly revised and a check shall be made to ensure that the equipment selection corresponds to the revised area classification.

20. A system shall be established to record the results of all inspections and the action taken to correct defects.

### 8.11 PRECAUTIONS DURING LOADING AND UNLOADING OF PETROLEUM TANKERS

1. In the loading and unloading area all pipe-lines, fittings and delivery hoses or metal pipes, metallic loading arms, swivel joints, tanks, chassis of tankers shall be electrically continuous and be efficiently earthed.

2. No mechanically propelled tankers shall be loaded or unloaded until its engine has been stopped.
stopped and battery isolated from electrical circuit. The engine shall not be restarted and the battery shall not be connected to the electrical circuit until all tanks, and valves have been securely closed: Provided that where special conditions exist which make compliance with any provisions of this sub-regulation not reasonably practicable, the Chief Inspector may by an order in writing and subject to such conditions as he may specify therein, grant relaxation from the said provisions.

3. Adequate Fire-Fighting equipment shall be kept readily available during loading of tankers for immediate use.
FORMAT – I

LOG SHEET FOR MINES AND OIL-FIELDS

[See sub-regulation (9) of regulation (110), clause (a) and (b) of sub-regulation (5) of regulation (115)]

Daily Log sheet for

(1) Name of Electrical Supervisor

(2) Report as to :-

(a) Condition of the insulation of the system.

(b) Specified detects of insulation (particulars of each failure of apparatus should be given).

(c) Accidents or dangerous occurrence (including any cases of electric shock and any cases of open sparking in apparatus in use in places where regulation 110 applies.

(d) Disconnection and reconnection of supply as required by sub-regulation (9) of regulation 110.

(e) Examination of earth fault detectors or recorders as provided by sub-regulation (3) of regulation 100.

(f) Examination of apparatus as provided by Regulation 115.

(i) Routine examinations as required by clause (a) of sub-regulation (5) of regulation 115.

(ii) Special examination* as required by clause (b) of sub-regulation (5) of regulation 115.

(3) Remarks:-

Signed

Examined by

Electrical Supervisor:

Engineer:

Manager:

*State which apparatus has been examined or tested and result.

NOTE:- This log sheet should be filled in as completely as possible. If, for instance, there are no defects of insulation to report, the word ‘none’ should be written in the vacant space.

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FORMAT - II

(NAME OF COMPANY)

(ELECTRICAL SAFETY IN ONSHORE PRODUCTION INSTALLATIONS IN E&P SECTOR)

(Electrical Isolation / Energisation Permit)

Section-A: Isolation Permit.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Request for Isolation</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time:</td>
<td></td>
</tr>
</tbody>
</table>

Department / Section / Area issuing the permit

Equipment number to be isolated:

Name of the equipment / circuit to be isolated:

The above-mentioned equipment / circuit shall be de-energized and isolated from all live conductors to carry out the maintenance work by section / for operational requirement.

<table>
<thead>
<tr>
<th>Issuer Name</th>
<th>Designation</th>
<th>Signature</th>
</tr>
</thead>
</table>

Certificate of Isolation:

<table>
<thead>
<tr>
<th>Date</th>
<th>Time:</th>
</tr>
</thead>
</table>

Certified that Equipment / Circuit no. of plant has been electrically isolated by switches / isolators / links / fuses (tick as applicable) and the danger tag is put on the supply panel. Actions in respect of electrical isolation have been recorded in the electrical shift logbook.

<table>
<thead>
<tr>
<th>Name of Authorized Person</th>
<th>Designation</th>
<th>Signature</th>
</tr>
</thead>
</table>

Section-B: Energisation Permit.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Request for Energisation</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time:</td>
<td></td>
</tr>
</tbody>
</table>

Department / Section / Area issuing the permit

Equipment number to be energized:

Name of the equipment / circuit to be energized:

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Work on the above mention equipment / circuit has been completed and all the applicable permits closed. This equipment / circuit may be energized.

<table>
<thead>
<tr>
<th>Issuer Name</th>
<th>Designation</th>
<th>Signature</th>
</tr>
</thead>
</table>

Certificate of Energisation:  
Date:  
Time:

Certified that Equipment / circuit no. of plant has been electrically energized and the danger tag removed from the supply panel. This is also recorded in the electrical shift logbook.

<table>
<thead>
<tr>
<th>Name of Authorized Person</th>
<th>Designation</th>
<th>Signature</th>
</tr>
</thead>
</table>

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9.0 DOCUMENTATION

1. DISPLAY OF CAUTION BOARDS:
   i. Electrical Caution Board on electrical equipment when under maintenance or repair
      "DO NOT OPERATE, MEN WORKING ON LINE"
   ii. Notice for restricted entry in Electrical control room / Substation
      "ENTRY OF UNAUTHOURISED PERSONS PROHIBITED"

2. DISPLAY AT SUBSTATION/ CONTROL ROOM:
   i. Single line diagram
   ii. Hazardous area classification of the location
   iii. Electrical Shock Treatment Chart
   iv. Important / emergency telephone numbers
   v. Isolation / lock -out tags
   vi. Escape route

3. RECORD KEEPING (AS APPLICABLE):
   i. Attendance Register
   ii. Shift Roster
   iii. List of trained First Aid & Firefighting personnel
   iv. List of persons with Electrical License (wiremen & supervisory)
   v. Accident Records
   vi. Log Book & equipment maintenance record
   vii. Daily check list of electrical equipment
   viii. Earth Resistance & Insulation Resistance Record
   ix. Work Permits
   x. Lay out Drawings
      • Equipment
      • Cable
      • Earthing

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10.0 REFERENCES

The following codes, standards and publications have either been referred to or used in the preparation of this document and the same shall be read in conjunction with this document:

1. OISD Standards / Recommended Practices:
   a. OISD-STD-216 “Electrical safety in Onshore drilling and workover rigs”
   b. OISD-RP-147 “Inspection, and safe practices during Electrical Installation”.
   c. OISD-STD-137 “Inspection of Electrical Equipment
   d. OISD-RP-149 “Design aspects for safety in electrical system”
   e. OISD-STD-155 “Personal protective equipment”
   f. OISD-GDN-192 “Safety practices during construction”
   g. OISD–GDN-180 “Lightning protection”
   h. OISD-STD-105 Work Permit System
   i. OISD-STD-127 Selection operation inspection and maintenance of Diesel Engines
   j. OISD-STD-189 Standard On Fire Fighting Equipment For Drilling Rigs, Work Over Rigs And Production Installations

2. CEA regulations, 2010

3. The Petroleum Rules, 2002

4. Oil Mines Regulations, 1984

5. BIS (Bureau of Indian Standards) Publications
   * IS 5571 Guide for selection of electrical equipment for hazardous areas.
   * IS 5572 Classification of Hazardous area having flammable gases and vapours for electrical installation.
   * IS 7820 Electrical Apparatus for Explosive Gas Atmospheres - Method of Test for Ignition Temperature
   * IS 3043 Code of Practice for Earthing.
   * IS 2309 Code of practice for the protection of buildings and allied structures against lightning
   * IS 15652 Insulating mats for electrical purposes

6. DGMS letter No. 1 (6) 2001- Genl / 3604 -3753

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PERSONAL PROTECTIVE EQUIPMENT (PPEs)

Any employee who works in/around energized equipment and has the potential to come into contact with "live" exposed parts must be provided and use Personal Protective Equipment (PPE). The following are basic guidelines for the proper use of electrical PPE.

- PPE must be designed for the work being performed. You must make sure that electrical gloves, insulated tools, etc. are rated for the voltage levels they will be used around. Electrically rated tools will be clearly labeled with the amount of voltage for which they are approved.
- Always inspect your electrical tools and PPE before each use to make sure they are in good condition. For periodicity of inspection, OISD STD 137 to be referred.
- Utilize approved fuse handling equipment that is insulated for the circuit voltage to remove or install fuses.
- All test instruments and equipment (volt, ammeters, ohm meters) and associated leads, cables, power cords, probes, and connectors must be visually inspected for external defects and damage before the equipment is used.

Following minimum tools/equipment should be maintained for electrical operation/maintenance activities viz.
- Hand Gloves
- Insulating mats conforming to IS:15652
- Safety Shoes
- Fuse handling equipment
- Goggle/Face Shield
- Electrical discharging/Earthing Rod
- Gas masks (for generating station with capacity 5MW or above)
- Safety helmet
- Safety Belt
- Safety Torch

OISD-STD-155 on “Personal Protective Equipment” to be referred for details on selection, use and maintenance of electrical PPEs.

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### SIZE OF EARTHING CONDUCTOR

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Type of equipment</th>
<th>Earth conductor size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Motors upto 3.7 KW</td>
<td>No. 8 SWG Solid GI Wire</td>
</tr>
<tr>
<td>2</td>
<td>Motors 5.5 KW to 30 KW &amp; welding receptacles</td>
<td>10 mm (3/8&quot;) dia. GI Wire Rope</td>
</tr>
<tr>
<td>3</td>
<td>Motors 37 KW and above including HV Motors</td>
<td>16 mm (5/8&quot;) GI Wire Rope/ 40 mm X 5 mm GI Strip</td>
</tr>
<tr>
<td>4</td>
<td>Building Columns</td>
<td>40 mm X 5 mm GI Strip</td>
</tr>
<tr>
<td>5</td>
<td>Storage Tank (Vertical &amp; Horizontal)</td>
<td>40 mm X 5 mm GI Strip</td>
</tr>
<tr>
<td>6</td>
<td>Loading Racks</td>
<td>40 mm X 5 mm GI Strip</td>
</tr>
<tr>
<td>7</td>
<td>Pipe racks, Vessels &amp; Heat Exchangers</td>
<td>40 mm X 5 mm GI Strip</td>
</tr>
<tr>
<td>8</td>
<td>Small Equipment &amp; Instruments</td>
<td>No. 8 SWG Solid GI Wire Rope</td>
</tr>
<tr>
<td>9</td>
<td>Lighting, Power &amp; Instrument Panels</td>
<td>10 mm (3/8&quot;) dia. GI Wire Rope</td>
</tr>
<tr>
<td>10</td>
<td>Main Earth Bus/MV &amp; HV Switch Gear Interconnections/</td>
<td>As Calculated</td>
</tr>
<tr>
<td></td>
<td>Power Transformer</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>EHV &amp; HV Sub-Stations</td>
<td>As Calculated</td>
</tr>
<tr>
<td>12</td>
<td>Push Button Stations</td>
<td>No. 8 SWG Solid GI Wire</td>
</tr>
<tr>
<td>13</td>
<td>Street Light Poles</td>
<td>10 mm (3/8&quot;) dia. GI Wire Rope</td>
</tr>
<tr>
<td>14</td>
<td>Lighting Transformer</td>
<td>16 mm (5/8&quot;) dia. GI Wire Rope</td>
</tr>
<tr>
<td>15</td>
<td>Bonding of Pipe</td>
<td>25 mm² insulated flexible copper cable</td>
</tr>
</tbody>
</table>

**Note:**

1. Earth connections to individual equipment from nearest earth plate/ grid may also be done alternatively using Aluminum/ Copper conductor PVC insulated core of size not less than half the cross-section of respective power cable to the equipment (Motor, Panel etc.). Connections shall be made using crimped type of lugs.
2. Earth rods and conductors shall be designed to cope with the conditions imposed. The earth conductor shall be adequately sized to carry the applicable maximum earth fault current without undue temperature rise. All joints shall be protected against corrosion.
3. All the electrical equipment operating above 250 volts shall have two separate and distinct connections to earth grid.
4. The cross sectional area of earthing conductor shall be minimum 4 sqmm.

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