




OGDCL PAKISTAN:
OIL & GAS DEVELOPMENT
COMPANY LIMITED

KPD-TAY COMPRESSION PROJECT

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**SPECIFICATION FOR
ELECTRICAL INSTALLATION WORKMANSHIP**

CLIENT : OIL & GAS DEVELOPMENT COMPANY LIMITED

PROJECT : KPD-TAY COMPRESSION PROJECT

**SPECIFICATION FOR
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1. INTRODUCTION

This specification covers the minimum acceptable standards of electrical installation workmanship, materials and construction methods required in the execution of electrical works for **KPD-TAY Compression Project**; which deemed necessary for defining minimum requirement at preliminary stage and shall not be considered comprehensive and final for execution. This specification does not absolve the CONTRACTOR from his responsibility of executing overall electrical works as stipulated in "Section 4" for complete installation, testing, performance, pre-commissioning and commissioning of overall electrical works complete in all respect. The CONTRACTOR shall develop the installation detail drawings for project electrical works including of on-skid and off-skid electrical equipment installation; and shall also develop the complete inspection, testing, commissioning plans based on this specification and submit to the COMPANY/CONSULTANT for approval during detailed engineering stage.

In case discrepancies are found between this specification and other documents, COMPANY/CONSULTANT shall be referred for correct interpretation.

1.1. Definition

Where used in this specification, the following terms shall have the meanings indicated below unless otherwise clearly indicated by context of their use.

COMPANY – Oil & Gas Development Company Limited (OGDCL)

CONCESSION REQUEST - A deviation requested by the CONTRACTOR usually after receiving the contract package. Often, it refers to an authorization to use, repair, recondition, reclaim, or release materials, components or equipment already in progress or completely manufactured but which does not meet or comply with COMPANY/CONSULTANT requirements. A Concession Request is subject to COMPANY/CONSULTANT approval.

CONTRACTOR - The party which carries out all or part of the design engineering, procurement, construction and commissioning (EPCC) or management of the project.

DRAWINGS - Drawings provided by the CONTRACTOR/VENDOR.

SUPPLIER/MANUFACTURER - The party which manufactures and/or supplies the material/equipment, and provides technical documents/drawings and services to perform the duties specified by the COMPANY/ CONTRACTOR.

PROJECT – KPD-TAY Compression Project



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1.2. Errors & Omissions

- The review and comment by COMPANY/CONSULTANT of any CONTRACTOR's/VENDOR's drawings, procedures or documents shall only indicate acceptance of general requirements and shall not relieve the CONTRACTOR/VENDOR of its obligations to comply with the requirements of this specification and other related parts of the Contract Documents.
- Any errors or omissions noted by the CONTRACTOR in this Specification shall be immediately brought to the attention of COMPANY/CONSULTANT.

1.3. Deviations

- All deviations to this Specification, other related specifications or attachments shall be brought to the knowledge of COMPANY/CONSULTANT as a section in the bid. All deviations made shall be with written approval of COMPANY/CONSULTANT prior to execution of Work. Such deviations shall be shown in the documentation prepared by the CONTRACTOR.

1.4. Conflicting Requirement

- In the event of any conflict, inconsistency or ambiguity between the CONTRACTORs scope of work, this Specification, Codes and Standards, and referenced in the Project Specification or any other documents, the CONTRACTOR shall refer to COMPANY/CONSULTANT whose decision shall prevail.

1.5. Reporting Procedure

- A reporting and documentation system shall be agreed between the CONTRACTOR and COMPANY/ CONSULTANT for the status of electrical works execution, installation, testing, inspection, performance, pre-commissioning and commissioning under this project. The CONTRACTOR shall provide reports and summaries for production performance and testing operations in conformance with a manufacturing schedule approved by COMPANY/CONSULTANT.
- Daily, weekly, monthly and run summaries of all major aspects of the on-going electrical works shall be provided as reports to COMPANY/CONSULTANT.

1.6. Unit Responsibility

- The CONTRACTOR shall be responsible for the complete installation, testing and inspection, pre- commissioning and commissioning of overall electrical works, including full compliance with all applicable design codes and standards, including of project reference document/drawings listed in Section-2 of this document and the requirements of the certifying authority, if applicable.
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- The CONTRACTOR shall guarantee that all the installation material and parts supplied and installed shall be new, unused and of the required/ specified grade.

1.7. Documentation

- Documents, drawings, calculation sheets, testing and inspection reports, project electrical works execution summary reports etc., to be submitted to the COMPANY/CONSULTANT shall be in English Language.
- Unless otherwise specified, the metric units shall be used in documents and drawings by the CONTRACTOR/VENDOR.
- The form of drawings and documents may be as per the CONTRACTOR/VENDOR's Standards. However, the format of the data sheet will be submitted to COMPANY/CONSULTANT for approval.
- Variations from or additions to this specification shall be called to the attention of the COMPANY/CONSULTANT and approved in writing by the COMPANY/CONSULTANT prior to starting manufacturing.
- Comments made by COMPANY/CONSULTANT on drawing/technical details submittal shall not relieve the CONTRACTOR/VENDOR of any responsibility in meeting the requirements of the specifications.
- Such comments shall not be construed as permission to deviate from requirements of the Purchase Order unless specific and mutual agreement is reached and confirmed in writing.
- The CONTRACTOR/VENDOR shall notify the COMPANY/CONSULTANT of any apparent conflict between this specification, the related data sheets, the Standards & Codes and any other specification noted herein. Resolution and or interpretation precedence shall be obtained from the COMPANY/CONSULTANT in writing before proceeding with the design manufacture.
- Variations from or additions to this specification shall be called to the attention of the COMPANY/CONSULTANT and approved in writing by the COMPANY/CONSULTANT prior to execution of the electrical works.

2. REFERENCE STANDARDS & CODES

Construction, installation, testing and inspection, pre-commissioning and commissioning of the electrical works under this project to be carried out by the CONTRACTOR shall comply with this General Specification for Electrical Installation Workmanship to be used in **KPD-TAY**



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Compression Project; and installation material selection shall confirm to the relevant and latest version of the following reference Standards and Codes.

It shall be manufacturer's responsibility to be, or to become, knowledgeable of the requirements of these reference Standards and Codes. Any changes, alteration and necessary re-certification of the equipment for compliance with the applicable Standards and Codes shall be at the expense of the Manufacturer.

DOC./DWG. NO.	DESCRIPTION
American Petroleum Institute (API)	
RP 505	Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2
RP 540	Electrical Installations in Petroleum Processing Plants
RP 2003	Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents
Institute of Electrical and Electronics Engineers (IEEE)	
841	IEEE Standard for Petroleum and Chemical Industry—Premium- Efficiency, Severe-Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors—Up to and Including 370 kW (500 hp)
International Electro-technical Commission (IEC)	
60034	Rotating Electric Machines
60074	Method for Assessing the Oxidation Stability of Insulating Oils
60079-14	Explosive Atmospheres - Part 14: Electrical Installations Design, Selection and Erection
60156	Insulating Liquids - Determination of the Breakdown Voltage at Power Frequency - Test Method
60364-5-52	Low-Voltage Electrical Installations - Part 5-52: Selection and Erection of Electrical Equipment - Wiring Systems
60423	Conduit Systems for Cable Management - Outside Diameters of Conduits for Electrical Installations and Threads for Conduits and Fittings
61537	Cable Management - Cable Tray Systems and Cable Ladder Systems
61936-1	Power Installations Exceeding 1 kV A.C. - Part 1: Common Rules
62305	Protection Against Lightning
62444	Cable Glands for Electrical Installations
British Standards	



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7430	Code of Practice for Earthing
National Fire Protection Association (NFPA)	
70	National Electrical Code

In the event of conflict between Standards, the most stringent shall prevail.

All standards, regulations and codes of practices used shall be of latest current issues at the date of contract award.

The CONTRACTOR shall be responsible for the availability of the above mentioned specifications/publications, standards, and codes of practices and any other relevant documents and shall collect these documents on its own. The CONTRACTOR shall make sure that these documents are available all times and shall submit/present to COMPANY/CONSULTANT on request.

3. SERVICE CONDITIONS**3.1. Site Conditions**

Equipment selection shall be based on the following environmental conditions:

PARAMETERS	VALUE/UNIT
MAXIMUM AMBIENT TEMPERATURE	118 °F
MINIMUM AMBIENT TEMPERATURE	36 °F
WET BULB TEMPERATURE (DESIGN)	88 °F
MAXIMUM RELATIVE HUMIDITY	77%
MINIMUM RELATIVE HUMIDITY	20%
DIRECTION OF PREVAILING WIND (ACROSS THE YEAR)	The prevailing wind directions are blowing from the North to the North-East
WIND VELOCITY (MAX. / NORMAL)	100mph Design velocity (mech. Design): 120mph Exposure factor C – flat open terrain, Importance factor 1.15 – essential facility
ELEVATION ABOVE MEAN SEA LEVEL (GPF)	21 m (69 ft.)
AIRBORNE DUST PARTICLES	Possible effect of airborne dust particles shall be considered when developing the design
SEISMIC ZONE	Zone 2A of Uniform Building Code- UBC-1997.
MAXIMUM DAILY RAINFALL	251mm (recorded over 24 hours)
MAXIMUM MONTHLY RAINFALL	286mm

3.2. Power Supply Characteristics

The rated characteristics of the power supplies are:



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PARAMETERS	VALUE/UNIT
VOLTAGE	400 V ac \pm 10%, 3-PHASE 230 V ac 1-PHASE
FREQUENCY	50 Hz \pm 2Hz
NEUTRAL SYSTEM	SOLIDLY EARTHED

4. SCOPE

This Specification covers the minimum acceptable standards of workmanship, materials and construction methods required in the execution of electrical works for **KPD-TAY Compression Project**.

The electrical works will comprise but not be limited to the following: -

- a) Installation of Gas Engine Driven Generators, generator's auxiliary panels and control panels along with complete termination, placement, alignment, pre-commissioning, commissioning, testing and performance of Gas Gensets etc., complete in all respect; shall be covered by the CONTRACTOR.
- b) Installation of Diesel Engine Driven Generators, generator's auxiliary panels and control panels along with complete termination, placement, alignment, pre-commissioning, commissioning, testing and performance of Gas Gensets etc., complete in all respect; shall be covered by the CONTRACTOR.
- c) Installation of Switchgear & Motor control center –VFDs/power distribution boards along with complete termination, placement, alignment, coupling works etc., complete in all respect and shall be covered by the CONTRACTOR.
- d) Installation of static dual redundant UPS unit, batteries, power distribution boards along with complete termination, placement, alignment, cabling works etc., complete in all respect and shall be covered by the CONTRACTOR.
- e) Laying, termination, glanding and testing of cables (complete for on-skid & off skid) including but not limited to following major runs; and shall be covered by the CONTRACTOR.
 - From Gas Engine Driven Generator/Auxiliary-Control Panels to Switchgear/MCC Panels.
 - From Diesel Engine Driven Generator/Control Panels to Switchgear/MCC Panels.
 - From Switchgear/MCC Panel to packages - field equipment.
 - From Switchgear/MCC Panel to UPS.
 - From UPS Distribution Board Panel to packages / field equipment.
 - From UPS Distribution Board Panel to Central Control Room (CCR).
 - Lighting Distribution Board to Field Lighting circuits (*up-to end light pole*).



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- f) Installation, cabling, testing etc. of complete Lighting system including pole mounted flood lights & structure lights for perimeter/area lighting and package skid lights etc., complete in all respect and shall be covered by the CONTRACTOR.
 - g) Installation, cabling, testing etc. of complete earthing system including direct driven in copper earth electrodes, complete inspection/testing earth pits, bare stranded / Yellow-Green PVC insulated copper stranded conductor, along with installation of earth termination bars, copper connectors (cad-weld as well as c-clamp compression type), termination, double compression type copper lugs etc., complete in all respect and shall be covered by the CONTRACTOR.
 - h) Installation, cabling, testing etc. of cathodic protection system including of transformer rectifiers etc. for underground services etc., complete in all respect and shall be covered by the CONTRACTOR.
 - i) Installation, cabling, testing etc. of lightning protection system including of air terminal lightning rods, mounting support arrangements, fixing, separate earth copper electrode, copper down conductors etc., complete in all respect and shall be covered by the CONTRACTOR.
 - j) Installation of Welding Outlet along with mounting stand and other installation accessories, complete in all respect and shall be covered by the CONTRACTOR.
 - k) Installation cabling, testing etc. of motor Local Control Stations (LCS) along with mounting stand and other installation accessories, complete in all respect and shall be covered by the CONTRACTOR.
 - l) Installation and testing of electrification works for skid shed etc., complete in all respect and shall be covered by the CONTRACTOR.
 - m) Installation of cable tray (ladder-type/perforated-type as per service) w.r.t package skid cable routing scheme along with, horizontal / vertical elbows, horizontal tees, fixing clips, joining/coupling plates etc and shall be covered by the CONTRACTOR.
 - n) This specification, related drawings, and referenced documents are intended to produce a complete and fully operable electrical system, equipment package, or facility in full compliance with applicable industry codes and standards, government regulations, and COMPANY/CONSULTANT's technical requirements and shall be covered by the CONTRACTOR.
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**SPECIFICATION FOR
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- a) The following documents are referenced herein and are considered part of this specification.
- b) Unless otherwise specified in Section 4.1 and/or Section 2, use the latest edition of the referenced documents.

In case discrepancies are found among this specification and other documents, COMPANY's/CONSULTANT's representative shall be referred for correct interpretation.

DOC./DWG. NO.	DESCRIPTION
0258-ELA-6500	Electrical Basis of Design
0258-ELA-6501	Electrical Load List (KPD / TAY @ GPP)
165-4-SPE-005	Specification for LV Switchgear/MCC
0258-ELA-6502	Specification for LV A.C Induction Motor
0258-ELA-6503	Specification for Power & Control Cables
0258-ELA-6504	Specification for Earthing & Lightning Protection System
0258-ELA-6505	Specification for Lighting Material
0258-ELA-6506	Specification for Uninterruptible Power Supply (UPS) System
0258-ELA-6507	Specification for Gas Engine Driven Generator
0258-ELA-6508	Specification for Diesel Engine Driven Generator
0258-ELA-6509	Specification for Building Electrification works
0258-ELA-6510	Data Sheet for LV A.C Induction Motor
0258-ELA-6511	Specification for Electrical Installation Workmanship
0258-ELA-6512	Electrical Load List (Thora-Deep-03 @ GGS)
0258-ELA-6513	Electrical Load List (TAY-03 @ GGS)
0258-ELB-6600 (SH# 1 of 2)	Legends and Symbols (Thora-Deep-03 GGS)
0258-ELB-6600 (SH# 2 of 2)	0.4kV LV SWG/MCC Single Line Diagram (Thora-Deep-03 GGS)
0258-ELB-6601	UPS-DB Single Line Diagram (Thora-Deep-03 GGS)
0258-ELB-6602 (SH# 1 of 2)	Legends and Symbols (TAY-03 GGS)
0258-ELB-6602	0.4kV LV SWG/MCC Single Line Diagram (TAY-03 GGS)



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(SH# 2 of 2)	
0258-ELB-6603	UPS-DB Single Line Diagram (TAY-03 GGS)
0258-ELB-6604	0.4kV LV SWG/MCC Single Line Diagram (KPD-GPP)
0258-ELB-6605	UPS-DB Single Line Diagram (KPD-GPP)
(3)G76003-A6585-5112-D	Single Line Diagram 102-MCC-03
0258-ELD-6700	Power Cable Route Layout (Thora-Deep-03 GGS)
0258-ELD-6701	Hazardous Area Classification Layout (Thora-Deep-03 GGS)
0258-ELD-6702	Switchgear/MCC Equipment Room Layout (Thora-Deep-03 GGS)
0258-ELD-6703	Power Cable Route Layout (TAY-03 GGS)
0258-ELD-6704	Hazardous Area Classification Layout (TAY-03 GGS)
0258-ELD-6705	Switchgear/MCC Equipment Room Layout (TAY-03 GGS)
0258-ELD-6706	Power Cable Route Layout- KPD @ GPP (FEC Area)
165-4-ELL-009	Electrical & Instrument Underground Trench Layout
0258-ELD-6707	Hazardous Area Classification Layout KPD @GPP (FEC Area)
165-4-ELL-031 (Sheets 2 of 5)	Hazardous Area Classification Layout KPD-GPP
165-4-ELL-018	Equipment Layout for MCC Building
165-4-ELL-015	Equipment Layout of Electrical Room in CCR Building (Existing)
0258-ELF- 6801	Typical Installation Detail Drawings

5. GENERAL

- 5.1. The installation work will be carried out on the site. The CONTRACTOR shall be held responsible for any damage caused to the existing equipment at site or when new equipment is left unattended. Any work mechanically complete should be adequately protected by the CONTRACTOR against dust, vandalism etc.
- 5.2. Upon completion of each part of the installation, the CONTRACTOR shall ensure that every item of electrical equipment is internally and externally clean, free from obstruction and ready for inspection, and that the site area is maintained in a clean and tidy condition.
- 5.3. Personnel engaged on the construction of electrical installations shall be fully qualified and competent tradesmen skilled in the particular activity in which they are engaged. The CONTRACTOR shall be prepared to give written proof or demonstrations of this requirement to the satisfaction of COMPANY/CONSULTANT.
- 5.4. Material and equipment supplied under this contract shall be new, comply with specifications, and where appropriate shall be provided with certificates issued by the National Certifying Authority for equipment in Hazardous Areas. All materials and equipment shall be subject to inspection and approval by COMPANY/CONSULTANT.



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- 5.5. Work in Classified Areas shall be carried out strictly in accordance with API RP 505 / IEC 60079 and with the site construction safety instructions. Particular attention shall be paid to the location and weather protection of EExd equipment.
 - 5.6. Care shall be taken at all times to ensure that the finished work has a good appearance, and that ready access is available to components. Particular attention shall be paid to the following:
 - 5.6.1. Thermal insulation and fire proofing materials, forming part of or applied to process lines, structures, etc. shall be left undisturbed. Damage, however caused, must be reported immediately.
 - 5.6.2. Work carried out prior to the application of thermal insulation and fire proofing materials, shall allow adequate clearances, and the work must be fully protected against possible damage during the application of thermal insulation and fire proofing materials.
 - 5.6.3. All electrical equipment and installations shall be located and/or protected against the effects of heat. A minimum clearance of 250mm shall be maintained between cable or conduits and the surface of the thermal insulation of any hot surfaces. For un-insulated hot surfaces the clearance shall be 500mm. Hot surface shall mean any surface, which would exceed the maximum ambient temperature that has been used for installation design.
 - 5.6.4. Acid resistant tiled surfaces shall not be cut, drilled or used for any fixing.
 - 5.6.5. The drilling, cutting or welding of pipe work, steelwork or building structures shall not be carried out without the prior approval of COMPANY/CONSULTANT.
 - 5.6.6. The CONTRACTOR shall make good any damage caused to building and paint finishes by his operations to the satisfaction of COMPANY/CONSULTANT.
 - 5.6.7. Equipment shall be protected from the hazards of general site construction and the elements.
 - 5.7. Correct, well-maintained modern tools and aids shall be used, as they are essential for a proper installation. Where special tools are available from equipment manufacturers, they shall be obtained in sufficient quantity so as not to delay the works.
 - 5.8. The IEE Regulations for Electrical Installations (Wiring Regulations), BS Codes of Practice, IEC Publications and manufacturer's instructions shall be observed and are not necessarily repeated in this specification except to emphasize or qualify a point.
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- 5.9. The CONTRACTOR shall be responsible to take the approval from electric inspector of all electrical installations like, distribution and earthing systems etc.
- 5.10. Prior to any Equipment being installed, it shall be the CONTRACTOR's responsibility to ensure that prepared foundations, supports, fixing arrangements, steel guide plates / runners are properly installed to suit the Equipment for which they are intended and to ensure that the finished Work has a good appearance and that ready access is available to all components. All dimensions associated with bolting down shall be checked to ensure that they comply with the manufacturer's arrangement drawings.

6. INSTALLATION OF GAS GENERATOR/ AND DIESEL GENERATOR

- 6.1. Installation and connection of gas engine driven generators, and diesel engine driven generators set with its auxiliaries etc. complete in all respects. The CONTRACTOR to provide testing and commissioning of the complete generator sets under the supervision of generator vendor. This shall include placement, alignment, levelling, cabling, termination, connections, glanding etc. It is the responsibility of the CONTRACTOR to install the following as minimum but not be limited to following:
- Gas engine coupled with alternator
 - Diesel engine coupled with alternator
 - Cooling system (table type radiator with electric motors and panel etc.)
 - Fuel & Exhaust systems
 - Ventilation and pressurization system etc.
- 6.2. The CONTRACTOR shall supply the installation of material like nuts, bolts, washers, MS- base plates, MS-channels and any other material required for complete installation of gas engine driven generator, and emergency diesel engine driven generator and associated systems, gas gen-sets auxiliary panel, control panels, piping etc. complete in all respects. In other words complete installation of generator set is required as per the standard practices and codes.

7. SWITCHGEAR & MOTOR CONTROL CENTERS

- 7.1. Equipment within this category is generally factory assembled and erected on site by the CONTRACTOR. They shall be fastened firmly and rigidly. All the erection work shall be as per Manufacturer's instructions and as approved by COMPANY/CONSULTANT.
- 7.2. During all stages of work, coordination is necessary to ensure the accurate location and alignment of equipment foundations, channels and fixing bolts with the Manufacturer's and Project Drawings.
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- 7.3. During the course of work it is necessary to ensure that all equipment is protected from the normal hazards that arise on construction sites (e.g. dust, condensation, mechanical damage etc.).
- 7.4. Anti-condensation heating may be required during the construction period. Temporary warning labels shall be attached to all heated equipment.
- 7.5. All damage to equipment finishes shall be touched-up/repaired to the satisfaction of the COMPANY/CONSULTANT.
- 7.6. It is the responsibility of the CONTRACTOR to provide all appropriate tools, equipment and materials required for the satisfactory installation.
- 7.7. Refer equipment arrangement layouts to be updated by the CONTRACTOR.
- 7.8. The power and control cables shall be connected as per cable manufacturer instruction. Cable glands shall be used to hold the cables. The armour wire shall be connected to the armour clamps of the gland for effective grounding.
- 7.9. Bus bars shall be fastened to the main buses of the switchboard. Care should be taken that phase identification colours of the bus-duct bars and the switch-board bars shall be matching. All the work shall be carried out as instructed by the Manufacturer.
- 7.10. All relay elements shall be adjusted or set as per details given on drawings or as per operating requirements.
- 7.11. LV Switchgear and Motor Control Center shall be tested after installation.

8. CABLE INSTALLATION

8.1. General Requirements

- 8.1.1. Cable routes detailed in the project reference drawings and specifications will have been selected to avoid areas likely to be subject to contamination. Cable routes not detailed on drawings shall also comply with the above and be agreed with COMPANY/CONSULTANT before starting the installation. Changes to approved cable routes shall only be made with the prior approval of COMPANY/CONSULTANT.
 - 8.1.2. Withdrawal spaces and dropping areas will have been shown, where specific allowances have been made. When routing cables, care must be taken not to obstruct these locations, nor to impede access to, and movement of any plant.
 - 8.1.3. Storage and handling of cable before and during installation shall take account of ambient conditions and manufacturer's recommendations. Cable drums shall be rotated only in the
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direction indicated by drum markings and open ends of cable are to be effectively sealed immediately after cutting to prevent the ingress of moisture. Open cable ends, in outdoor installations shall be protected by heat shrink end caps.

- 8.1.4. At all times the utmost care is to be exercised to avoid damaging the protective sheathing of cable or the causing of excessive bending or twisting which may result in bird caging of wire armor or damage to core insulation and sheaths. The manufacturer's minimum bending radii for cables shall be observed at all stages of the installation.
 - 8.1.5. Under no circumstances shall metal levers or tools be used in direct contact with cable during installation unless of a proprietary type specifically designed for the purpose.
 - 8.1.6. Cable shall be run in continuous unbroken lengths and joints will not be permitted unless the route length exceeds the maximum manufactured drum length, or there is specific authorization for jointing of the cable by COMPANY/CONSULTANT.
 - 8.1.7. Where cables pass through floors, or rise from grade level they shall have mechanical protection in the form of sleeves or kick plats projecting not less than 150mm above floor level, unless otherwise indicated. Kick plates shall be positioned so that they will not cause trip hazards. Where mobile equipment will be used in normal plant operation e.g. warehouses and loading areas, this protection shall extend to 2 meters and warning labels shall be fitted.
 - 8.1.8. Where cables pass through gas, dust or fire barriers, the hole provided for them shall be sealed as required by the IEE Wiring Regulations with cable transits, gland plates or proprietary systems as detailed in the drawings.
 - 8.1.9. All cables other than lighting and small power sub-circuits shall be identified and tagged at each end adjacent to their termination point with approved markers on carrier strip. In addition, all underground cables shall be fitted with non-corrodable identification bands at all points where they enter or leave buildings, cable ducts, trench ducts or similar. Steel tags shall be provided at every 15 meter distance. Lighting and small power sub-circuit cables shall be identified at each luminaries/socket outlet.
 - 8.1.10. Cables of power systems shall be segregated from intrinsically safe, electronic instrumentation and communication circuits in accordance with the relevant specification issued for the job and the drawings bearing the general notes for power and lighting installations.
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8.1.11. Cables will be de-rated, during design, for method of installation and the arrangements detailed in the approved drawings shall be strictly adhered to unless changes are agreed upon by COMPANY's /CONSULTANT's representative.

8.1.12. Each cable shall be subjected to an insulation resistance and continuity test after installation and prior to final dressing into position and termination; results shall be recorded and approved by COMPANY/CONSULTANT.

8.1.13. Cables shall be located and dressed into their final positions as work proceeds. The practice of pulling all cables on a route and then attempting to tidy up afterwards will not be accepted. The CONTRACTOR shall be responsible for proper dressing of cables.

8.2. Direct Buried Cables Underground & Paved Trenches

8.2.1. This shall be the responsibility of the CONTRACTOR to verify the marked cable route w.r.t measurement of road crossing, drain water channel/sewerage lines and/or other underground utility services (i-e pipelines - water or gas lines, instrument cable trenches, cable crossings w.r.t instrument/communication cables) that are falling on marked electrical power & control cable trench routes are being carried out; shall be identified and rectified accordingly after review of plant mechanical piping layout (above & underground installation) and other project civil drawings.

8.2.2. If any obstruction/crossing occurs, suitable precautions, or alternate cable route shall be proposed as far as practicable shall be made in light of governing standards & codes, and project specification with the approval of COMPANY/CONSULTANT. Approval may at sole discretion of COMPANY/CONSULTANT and the CONTRACTOR is liable to incorporate in letter and spirit, without any additional cost.

8.2.3. Cable trenches (Direct Buried) shall be prepared as marked in project cable route layout for laying of power & control cables (Cu/XLPE/PVC/SWA/PVC type) from SWG/MCC Room to field equipment/skid packages, buildings/sheds and all other auxiliary loads to be identified during the detailed engineering.

8.2.4. Cable routing schemes and detailed cable schedule w.r.t packages/vendor skids individually shall be developed/prepared respectively by the CONTRACTOR, and shall be submitted to COMPANY/CONSULTANT for review and approval.

8.2.5. The CONTRACTOR shall be responsible for clearance of all obstacles in laying before, during and after execution including drainage/pumping of water from trench to ensure suitability of the cable trench for cable laying.



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- 8.2.6. The clearance of debris or any other material laying in the route of the cable shall be the responsibility of the CONTRACTOR.
 - 8.2.7. After the trench has been properly made, proper bedding for laying the cable shall be made in accordance with the submitted typical installation details of trench.
 - 8.2.8. Minimum separation in between new cable trench and other underground utility services shall be maintained as shown in to typical installation detail drawings.
 - 8.2.9. During the execution of cable laying, CONTRACTOR shall maintain the minimum 300mm space, where the power cable trench runs in parallel with the plant control or communication cables (either laid in same trench or runs separately).
 - 8.2.10. This shall be ensured by the CONTRACTOR that power cable trench crossing w.r.t plant control cables/ or communication cables shall be made at 90°.
 - 8.2.11. During execution while performing electrical works, extra care shall be exercised by the CONTRACTOR to avoid any damage to existing/ or new mechanical and civil structures, any damage to above shall be born and replaced solely by the CONTRACTOR.
 - 8.2.12. During execution for the laying of power & control cables in to trenches, the CONTRACTOR shall ensure that cable bending radius shall not be less than that specified by the cable manufacturer.
 - 8.2.13. Whenever cable is to be laid across road crossing, cable shall be laid inside g.i pipe of 6" inches dia/or high strength PVC Class D conduits. At sub/branch road crossing, in front of gate of residential camps, sewerage/drains crossing; cable shall be laid inside "Hume Pipes" (R.C.C) with the sole approval of COMPANY/CONSULTANT. Sufficient spare conduits shall be considered and installed for accommodation of power & control cables in future.
 - 8.2.14. Cable markers shall be provided throughout the cable route as per submitted typical installation details spacing at every 20m. Cable markers shall be provided and installed at all direction changes, intersection and straight runs.
 - 8.2.15. Each of the cable drums will be tested for continuity & insulation test.
 - 8.2.16. Power & control cables shall run in g.i stub-type conduits where cables rise from ground to field equipment i-e motors, junction boxes, welding sockets, distribution board, and local control stations (LCS) etc.
 - 8.2.17. Distribution of power cable trenches/lighting circuits on pipe-rack shall be via cable tray.
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- 8.2.18. Distribution of power & control cables/lighting circuits on plant skids shall run on cable tray or g.i conduits, to be finalized during detail engineering by the CONTRACTOR.
- 8.2.19. Power & control cable trench shall have a clearance of at least one (1) meter from the road shoulder.
- 8.2.20. Power & control cable/lighting circuit section details w.r.t. reference cables identification shall be developed/marked on the updated layout by the CONTRACTOR.
- 8.2.21. After laying and energization of the cable, the finalized drawings in triplicate shall be prepared/updated on auto-cad with soft copy on CD along with hard copy shall be submitted to COMPANY/CONSULTANT.
- 8.2.22. The submitted drawing shall include necessary information i-e physical direction, glossary, roads, and other structures, route of cable, g.i pipes, hume pipes, clearances from other plant skids/packages side, roads, etc., shall be clearly indicated in the cable laying route drawings.
- 8.2.23. Cables must be laid in existing power cable trench (to be evaluated/confirmed during the detail engineering by the CONTRACTOR) in accordance with the specified or agreed route as marked in project reference drawings. If deviation w.r.t marked cable route is necessary for any reason, authority must be obtained in the form of the COMPANY/CONSULTANT's written approval.
- 8.2.24. Due to non-availability of space in existing cable trenches to accommodate the new power & control cables as per new scope of work, then extension of existing trenches shall be made w.r.t. marked dimensions on layout, and shall be finalized during the detail engineering by the CONTRACTOR.
- 8.2.25. Surface route markers shall be installed as shown on the installation details but in any event at not more than 30 meter intervals and at significant changes of direction.
- 8.2.26. The excavation, sanding, tiling and back filling of trenches for the installation shall be carried out by the CONTRACTOR as per typical installation detail drawing submitted in tender document w.r.t. cable trenches details, and shall be strictly followed by the CONTRACTOR.
- 8.3. Cables Installed above Ground**
- 8.3.1. Cables installation above ground shall run on continuous cable tray (ladder type), if any requirement occurs during the detail engineering w.r.t new skids/packages. For branches from the cable tray or when cables are small in number, cables shall be protected by
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perforated cable tray or steel conduit with COMPANY/CONSULTANT's approval. Cable tray (ladder type) systems shall be selected for maximum resistance to environmental corrosion.

- 8.3.2. The CONTRACTOR shall carefully check the cable tray (ladder type) locations shown on the COMPANY/CONSULTANT- accepted drawings for possible interference with other equipment, such as steelwork, piping, and ducting. Cable tray (ladder type) accessories e.g., nuts, bolts, and clamps shall be of 316 stainless steel material.
- 8.3.3. Cable tray (ladder type) supports shall be spaced along cable tray length in a manner that prevents sagging and misalignment of cable tray under maximum design load.
- 8.3.4. Supports for cable trays (ladder type) shall be standardized and shall conform to the type and arrangement of main cable run supports.
- 8.3.5. Cable trays shall be bolted or clamped to supports with 316 stainless steel bolts or clamps. Welding of trays shall not be permitted.
- Structural members shall not be drilled for purposes of securing trays unless called for on COMPANY/CONSULTANT accepted drawings, or unless authorized in writing by COMPANY's /CONSULTANT's representative.
 - Any drilling authorized as cited above shall be done in a manner to minimize effect on the strength of the structural members being drilled.
- 8.3.6. Cable trays shall not be used as walkways or scaffolding, or for any other purpose for which they are not intended.
- Cable trays shall not be used as a means of support for other raceways, cables, or non-electrical equipment.
 - The CONTRACTOR shall be responsible for correcting any damage incurred to cable trays to the satisfaction of COMPANY's /CONSULTANT's representative.
- 8.3.7. Cable trays (ladder type) shall be cut only along a line of plain metal and not through any perforation.
- After cutting, sharp edges shall be smoothed and, where applicable, the finish shall be restored.
 - Exposed steel shall be treated with a cold-galvanized treatment, including hot-dip galvanized steel trays.
- 8.3.8. Cable tray fittings shall provide a smooth and tangential transition between cable tray elements.
- 8.3.9. Electrical continuity shall be maintained at joints between sections of metallic cable tray.
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- Metallic cable trays shall be bonded to the support structure at intervals not exceeding 50 feet (15 m).
- If cables leave one tray and enter another, a bonding jumper shall be installed between cable trays section.

8.3.10. Cable trays may be installed without top covers allowing adequate ventilation except where:

- Mechanical damage of the cables is likely to occur during plant maintenance.
- Chemical spillage or the trap can be expected.

8.3.11. It is only permitted for cable route with one cable to install directly on the surface of structure or wall without tray. All cables for installation on surface of wall, column, ceiling, channels, etc., shall be fixed to the surface by means of non-corrosive, non-flammable P type clips, secured to a steel channel using suitable stud plate, nuts and washers. Common mounting channels are to be furnished for cable along the same route.

8.3.12. The erection of cables and position of support shall be so arranged that cable crossing one another be minimized, if cannot be avoided.

8.3.13. Cables and Equipment fixed to a building fabric, i.e., brick Work, concrete, etc. shall be fixed by means of appropriate fixing devices, i.e., rawl bolts, hilti fixing devices, etc.

8.3.14. Grease or other injurious lubricants shall not be used in pulling cables. The use of talc or non-injurious lubricants is permissible, if desired.

8.3.15. Each cable shall be supported and secured in a manner, which minimizes sagging and ensures that no strain is imposed on the terminations.

8.3.16. Cable routes shown on project reference drawings (to be finalized during detail engineering by the CONTRACTOR) shall be selected to avoid areas subject to risk of damage from fire, leakage or spillage.

8.3.17. Cables above 35mm diameter shall be individually cleated. Cables up to 35mm diameter shall be arranged in bank but shall not form more than two layers. Bunching of cables will not be permitted. Spare capacity of 20% shall be allowed on all cable trays (ladder-type).

8.3.18. Cables passing from a pressurized enclosure or building or through a firewall leading from a safe to a hazardous area shall be sealed.

8.4. Cable Supports and Fixings



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- 8.4.1. The cables tray (ladder type) system shall be mechanically continuous as far as practicable. The length of a gap shall be limited to the width of the pipe rack or tray involved, the ends of which shall be rigidly supported.
- 8.4.2. Cable tray shall be heavy-duty mild steel, galvanized, of minimum thickness 2mm up to 300mm width with 100mm depth / height. The minimum width installed shall be 100mm.
- 8.4.3. Manufactured junction pieces, bends and the like, shall be used in cable tray (ladder type) runs wherever possible. Where site fabrication is permitted they shall be of equal quality, strength and dimensions.
- 8.4.4. Electrical continuity throughout the runs of cable tray (ladder type) and steel cable supports shall be ensured. Proprietary bonding links shall be used wherever necessary. Gaps in cable supports shall have earth-bonding connections.
- 8.4.5. All runs of cable and supporting systems shall be installed such that water cannot collect or remain in any part.
- 8.4.6. Cable tray (ladder type) shall be secured at intervals laid down in the IEE Wiring Regulations or cable manufacturer's recommendations. Cables secured individually shall be fixed with non-corrodable, non-flammable P-clips or cleats. Cables shall be fixed throughout their length by means of approved saddles, cable clips, etc., at every 4m horizontally and 1m vertically. Hardwood will not be permitted. Cables in bank shall be strapped overall with PVC covered galvanized steel strip (e.g. "All Round Bank") and cadmium plated screws, washers and nuts. Fixings for banks of cables shall be spaced for the smallest cross-section cable in the group. All cable fixings shall be secure without such excessive pressure that would cause damage to the cable sheath.
- 8.5. Cable Termination and Jointing**
- 8.5.1. All jointing and termination work shall be carried out by practicing, fully trained tradesmen, qualified in such work for the operating voltage concerned. Written proof and/or demonstration of this may be required from COMPANY/CONSULTANT.
- 8.5.2. Jointing and termination work must be carried out using crimped compression type conductor connections where lugs or wire pins are required and mechanical compression glands. Soldering methods should not be employed in order to avoid insulation damage due to the application of excessive heat compression tools and dies shall be designed and supplied for specific use with the connectors used and shall be maintained in order and used in accordance with the manufacturer's instructions.
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- 8.5.3. Glands for use in hazardous areas shall be installed in accordance with IEC 60079 and have component approval for use with the associated cable and the type of protection (e.g. EExd) and apparatus grouping of the certified / approved equipment. The installer shall use the specific types identified in the cable schedule.
- 8.5.4. The degree of protection of equipment enclosures (IP) shall be maintained at cable entries. Protection against ingress of moisture shall be provided by one of the following preferred methods:
- Tapped entries – threads shall be sealed using an application of component approved sealing compound or grease.
 - Clearance hole entries – fiber sealing washers shall be fitted externally between the gland body and gland plate/enclosure.
- 8.5.5. Sealing washers may also be used on equipment with tapped entries. On EExd certified equipment the required number of full threads of engagement must be ensured.
- 8.5.6. The glands shall be assembled strictly in accordance with the manufacturer's instructions, particular attention being paid to ensuring good mechanical and electrical contact between parts without excessive stain or distortion of the cable.
- 8.5.7. Glands made off into equipment having a restricted breathing enclosure, must utilize the seals provided with the equipment, to ensure the effectiveness of this feature.
- 8.5.8. Electrical continuity between non-current carrying metal parts and the cable armour and/or metal sheath shall be ensured by the integrity of the gland termination which shall also preserve the type and the degree of protection of the enclosure. Where thread-sealing compounds are used they shall be of a conducting type such that the electrical continuity between gland and enclosure is maintained.
- 8.5.9. Where, cable entry is through a clearance hole, in an enclosure or gland plate of conducting material and finish, electrical continuity shall be maintained by fitting a serrated steel washer internally and securing the gland using a brass lock-nut. Alternatively, a brass earthing tag may be fitted (in place of the serrated washer) connected to an internal earthing stud/terminal. Where an enclosure or gland plate is of non or semi-conductive material or has a painted finish, a brass earth tag shall be fitted, in contact with the gland, for connection to an external earth terminal or in contact with the locknut for an internal earth terminal.
- 8.5.10. The entire body of the cable must enter the gland. The cable shall be on a straight axis from a point at least six diameters before entering the gland. Seals shall be checked for correct size at the point of application.
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8.5.11. Top cable entry shall be avoided wherever possible in outdoor installations. It is preferred that cables should be terminated at the bottom of enclosures. Where this is impractical they shall be terminated at the side; towards the on-driving end in the case of motors. A drop loop shall be formed in cables, at least six diameters from the gland.

8.5.12. Wherever safe and practical, the maximum amount of tail shall be left to enable future changes and the remaking of connections.

8.5.13. Tunnel type conductor terminals shall be of the clamp type i.e. not pinch screw. Not more than one single or multi-stranded wiring lead shall be connected into either side of any terminal. Conductor insulation shall extend to, but not enter, the metal throat of the terminal, and all terminal screws shall be tightened down.

8.5.14. Care shall be taken to ensure that creep-age and clearance distances are maintained e.g. no washers or loose strands.

8.5.15. Unused cable entries shall be closed with plugs suitable for the degree of protection of the equipment and having component approval for apparatus in hazardous areas.

8.6. Circuit Identification

8.6.1. In addition to cable identification cable cores shall be positively identified at every terminal point, in accordance with the drawings. Cables steel tags shall be provided at every 15 meters.

8.6.2. Three conductor circuits connected to a 3 phase, 3 wire system shall have Red, Yellow and Blue core colours.

8.6.3. Four conductor circuits connected to a 3 phase 4 wire system shall have Red, Yellow and Blue core colours for phases and Black colour for neutral core.

8.6.4. Two conductors connected to a single phase and neutral circuit shall have phase core coloured Red and neutral core Black.

8.6.5. Three conductors connected to a single phase and neutral with earth shall have the following core identification for 3 core PVC/SWA/PVC cables:

Phase conductor	Red/Yellow/Blue with red sleeve at all termination points.
Neutral Conductor	Black with black sleeve at all termination points.
Earth Conductor	Green with yellow sleeve at all termination points.

8.6.6. D.C. circuits shall have red colour for positive and black for negative conductor of 2 wire circuit D.C. circuit.



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- 8.6.7. For core identification at the terminations of cables, tapes, sleeves or dices shall be used duly coloured with appropriate colour.
- 8.6.8. Every core of a flexible cable or flexible core shall be identified throughout its length according to its function. Table 52B of I.E.E. Regulations for Electrical Installation 15th edition shall be followed along with its relevant notes.
- 8.6.9. Ferrules used for identification shall be of the interlocking permanently engraved type, designed to encircle the core completely. Markers of the adhesive type will not be permitted. Ferrules shall be correctly sized. There shall be no improvisation and engravings must not be altered.
- 8.6.10. Core markings shall be strictly in accordance with the drawings. Where references are not provided a system shall be agreed with COMPANY/CONSULTANT and recorded on the "As Built" drawings.
- 8.7. Cable Rule Laying Underground**
- 8.7.1. The cable trench shall be excavated if any requirement exists during the detail engineering. Wet or flooded excavations shall be de-watered and all mud removed before cables are installed. Before laying of cable and after the trench has been cleared of all loose earth and debris, the bed of the trench shall be levelled and filled with a 100 mm thick layer of stone free fine sand (1.3 min diameter maximum particle size). The sand layer shall be levelled and the cables placed thereon. The cables to be installed directly underground shall be laid in trenches in single tiers.
- 8.7.2. Sufficient slack shall be left in cables. The cables in the trench shall be arranged so as to minimise cables crossing where they leave the trench. Control cables shall be run next to power cables. The earth continuity conductor shall be laid in the trench with the cables.
- 8.7.3. The cables shall be covered with a layer of fine sand 100 mm thick measured from the top of largest cable. Cables shall be protected by means of cable warning tiles. The cable warning tiles shall be minimum 50 mm thick. These shall be laid 100 mm above the top of the cables to cover the entire length and breadth of the cable trench.
- 8.7.4. The depth of cable below finished ground level shall be 700 mm minimum measured from the top of the largest cable to the general ground level. The burial depth may be increased as required due to Site conditions or when crossing other service pipes and roads. A minimum clearance of 250 mm vertically and 500mm horizontally shall be maintained between cables and other services. These shall be effectuated at ninety degrees as far as possible. Burial depth less than 700 mm and more than 1500 mm shall require Owner's approval.
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- 8.7.5. After the warning tiles are placed, the remainder of the trench shall be back filled with earth in layer 400 mm thick (loose measurement). Each layer shall be thoroughly tamped and compacted.
- 8.7.6. Material for backfill shall be free of large lumps of stone, rock, concrete, debris, and foreign material. In general, material excavated for cable trench shall be suitable for back fill provided it is free from large lumps of stone, rock, concrete, debris, foreign material and the moisture content at the time of back fill is within acceptable limits so that the back fill material can be compacted. Level of trench after compaction shall be same for surroundings / adjacent areas.
- 8.7.7. Cables entering the buildings shall be laid in protective pipes. The protective pipe ends, after installation of cables, shall be plugged watertight.
- 8.7.8. Cables shall be pulled through duct bank system for road / dyke crossings. Duct bank shall be PVC or non-metallic pipes encased in concrete of thickness as specified by relevant codes and standards.
- 8.7.9. The top of the concrete encasement shall be at least 600 mm below grade when the duct bank cross the roads.
- 8.7.10. Cables shall not be pulled into ducts until the duct system has been completed, cleared and free from obstruction and sharp edges.
- 8.7.11. A clean rag or brush shall be drawn through each cable duct before cable is drawn in. Cables shall be put into ducts in such a manner that there will be no cuts or abrasions in the cable insulation, protective braid and jackets. There shall be no kinks in the conductors.
- 8.7.12. **Handling**

Damage to cable can occur due to incorrect handling to which the drums and cables may be subjected, causing breakdown of the drum flanges and in exceptional cases, movement of the drum barrel takes place. Once this breakdown of the drum occurs the cable shall be immediately exposed to damage.

Forklift trucks shall be used in handling provided that care will be exercised not to damage or remove the protective lagging when pushing the 'fork' under the drum flanges. Unloading can also be safely accomplished by means of ramps and winches. Under no circumstances should a drum be rolled off a vehicle on to a 'cushion' of sand, tarpaulin, etc. This action could crumple the flanges and barrel of the drum, driving splinters and / or nails into the cable.



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a) Rolling Drums

Drums of cable must always be rolled in the direction shown by the arrow painted on the flanges, but such rolling should in any case be kept to a minimum.

b) Turning Drums

The best way to turn a cable drum is to roll it on to two well-greased thin plates or boards about 2 feet square. The plates can then be used as a turntable and the drum rotated to the desired direction.

8.7.13. Lowering of Lifting Drums

When drums are moved from one level to another, e.g. truck to ground, wharf to ship, etc. lifting and lowering gear must always be used. When drum are lifted from the upper layer of a tiered stack, care must be taken to ensure that no movement of the bottom layer occurs so as to cause collapse. Drums, whether loaded or empty, and too heavy to be man handled, should always be slung; they should never be dropped. When lifting drums of cable for loading or unloading, spindles must always be used in conjunction with crane slings, chain or lifting beams. On no account any drum be lifted by wire slings.

When lifting drums of cables, lifting beams or stretchers between the sling of chain pairs must be used to prevent flanges crushing on to the cable.

Normally the hooks or slings should be close to the drum flanges.

8.7.14. Storage

If at any time the drums of cable are required to be stored for reasonably long periods, e.g. prior to shipment or installation, the following points should be noted.

- The site for storage of drums should be well drained, hard packed soil, or preferably a concrete surface, which will not allow the drums to sink and so give rise to damage due to the extreme difficulty in moving drums when they are sunk into the ground.
- All drums should be stored with the lagging intact, and in such a manner as to leave sufficient space between them for air circulation. Check and tighten barrel bolts on the drums at regular intervals.
- Tier stacking of drums is not recommended. In no circumstances must the drums be stored on the flat i.e. with flanges horizontal.
- All drums during installation (i.e. when the lagging have been removed) should be stored with the rims of flange touching, so that there is no danger of the flanges of drums coming into accidental contact with unprotected cable on other drums.
- Cable ends must be sealed with end cap during storage.

9. JUNCTION BOXES, DISTRIBUTION BOARDS



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- 9.1. All junction boxes shall be accessible from grade or walkway level. The cable or conduit connections shall be effectuated at the bottom, or possibly on the side, when the cable comes from the bottom.
 - 9.2. The locations of distribution boards shall be as per detail engineering design drawings. The actual location (w.r.t skid/package mounted/ or on field) shall be determined during the detail engineering by the CONTRACTOR keeping in view the site conditions and other equipment, as approved by the COMPANY/CONSULTANT.
 - 9.3. The surface mounting distribution boards shall be installed on surface and shall be anchored by means of bolts or steel channels as per manufacturer's instructions for installation.
 - 9.4. The distribution board shall be protected to avoid any damage due to civil Work.
 - 9.5. All loose parts dispatched separately with the distribution board shall be installed as per manufacturer instruction and all adjustments or settings shall be made as required. All screws, nuts and bolts used for fixing the distribution board shall be galvanized.
 - 9.6. The surface and recessed mounting distribution boards shall be installed at 5 feet height from finished floor level to the bottom of distribution boards, unless otherwise specified.
 - 9.7. The cable entry in the distribution boards shall be provided from top or bottom as required. Appropriate conduit / pipe entry holes made in the boards shall be equipped with cable glands to avoid danger to pulling cables. All incoming and outgoing cable connections shall be lightly made and special care should be taken in fixing cable lugs, and lead connections so as to have no danger of leakage during operation.
 - 9.8. All cable connections to circuit breakers, etc., shall be made neatly and firmly to ensure good contact and properly identified by the use of alphanumerical ferrules.
 - 9.9. During all stages of work, coordination is necessary to ensure the accurate location and alignment of equipment foundations, channels and fixing bolts with the manufacturer's and Project Drawings.
 - 9.10. During the course of work it is necessary to ensure that all equipment is protected from the normal hazards that arise on construction sites (e.g. dust, condensation, mechanical damage etc.).
 - 9.11. All damage to equipment finishes shall be touched-up/repaired to the satisfaction of COMPANY/CONSULTANT.
 - 9.12. The cable entry in the distribution boards shall be provided from top or bottom as required.
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- 9.13. All cable connections to circuit breakers, etc., shall be made neatly and firmly to ensure good contact and properly identified by the use of alphanumerical ferrules.
- 9.14. When outdoor apparatus is installed in open air, an extra protection of the type, by means of a cover, shall be fitted on the pedestal or supporting frame.



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10. LIGHTING & SOCKET OUTLETS

10.1. General Requirement

10.1.1. The CONTRACTOR shall develop lighting layout and mark the positions of luminaries and socket outlets, etc. Locations shall take into account adjacent pipe work and equipment and the luminaries positioned to provide the maximum use of the light output and access for maintenance. Any deviation w.r.t developed drawings shall be brought to the knowledge of COMPANY/CONSULTANT. Such deviations made (in documentation form shall be prepared by the CONTRACTOR) prior to execution of work shall be with written approval of COMPANY/CONSULTANT; and all changes shall be made/recorded on the 'As Built' drawings.

10.1.2. The locations of luminaries outdoors shall favour platforms, landings or stairways, ladders, gauges, indicating instruments.

10.1.3. Lighting switches shall generally be mounted 1500mm above floor level.

10.1.4. Socket outlets shall be mounted 1500mm above floor level, or as dictated by the location (e.g. supported from hand-rails).

10.1.5. Enclosures within 2 meters of each other and containing single phase circuits on different phases of the supply shall have their covers marked with their respective phase identifications. Where colours are used markings shall be distinguishable from other coloured identifications.

10.1.6. The CONTRACTOR shall erect, install, test and commission complete lighting system. The lighting system shall be installed as per project lighting layouts (to be developed during the detail engineering by the CONTRACTOR).

- The procurement & installation of all relevant materials and components inclusive of fittings, clamps, connector boxes, fuses, etc. necessary for lighting installations will be solely undertaken by the CONTRACTOR.
 - The CONTRACTOR shall be allowed for any small variations in the position of the lighting fittings as required by site conditions. Large alterations or modifications may be made with the approval of COMPANY/CONSULTANT.
 - The CONTRACTOR must ensure that the lighting, fittings are installed uniformly with respect to the dimensions of the area. All the fittings shall be carefully aligned before fixing in position, so as not to cause any undue damage.
 - Glasses, shades, reflectors, diffusers etc. must be in a clean condition after installation.
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- The CONTRACTOR is to manufacture, place in position and erect all lighting supports and brackets, make off and connect cables and install fittings as shown on drawings/Layouts (to be developed during detail engineering by the CONTRACTOR).
- All lighting fittings shall be earthed by an earth wire connected to the earth terminal in the fittings.

10.2. Installation of Lighting Distribution Boards

10.2.1. The lighting distribution board shall be installed in outdoor and safe location/ or occurs in classified area (to be finalized during detail engineering by the CONTRACTOR) as per project requirement. These may be installed on steel structure or steel structure column or steel channel provided by the CONTRACTOR.

10.2.2. The panel boards shall be installed at 5 feet height from finished floor level to the bottom of panel boards, unless otherwise specified in drawings and Documents.

10.2.3. Floor mounting distribution panel boards shall be installed at locations indicated on drawings.

10.2.4. The panel shall be fixed firmly on the floor according to the manufacturer recommendations.

10.2.5. All outgoing and incoming cable connections shall be tightly made and special care should be taken in fixing cable lugs, and lead connections so as to have no danger of leakage during operation.

10.2.6. Appropriate conduit/pipe entry holes shall be made in the panels and equipped with cable glands, and/or metal rubber, PVC or wooden bushes to avoid danger to pulling cables.

10.2.7. All cable connections to circuit breakers shall be made neatly and firmly to ensure good contact.

10.3. Lighting Pole on Concrete Foundation

10.3.1. Concrete pole foundation shall be made as per drawing of pole foundation. After the foundation is ready, anchor bolts shall be installed in the pockets left in the concrete foundation. The bolts shall be properly spaced and kept straight. The pockets shall be filled with cement and sand mixture to hold the bolts. As the bolts are fixed in position the pole foundation shall be ready for installation of lighting pole on it.

10.3.2. The lighting pole shall be erected vertically on the pole foundation taking care that the arm of pole shall be on the side where light fitting is to be installed.

10.3.3. The pole shall then be fastened to the anchor bolts using nuts. Two nuts shall be used to secure the lighting pole.



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10.4. Lighting Pole on Metallic Platform

10.4.1. The poles to be installed on metallic platform or stairs shall be properly clamped with the metallic structure by means of suitable size of U-bolt G.I. clamp, checking in vertical position of the pole by a plumb bob. The pole shall be welded to the metallic structure at the bottom by means of a pole support steel sheet of suitable dimensions.

10.5. Fixtures – Supports

10.5.1. The apparatus to be mounted by the CONTRACTOR shall be supported by iron profiles. These shall be Cadmium treated or galvanized, as shall the bolts, and shall preferably be of the perforated type, or so designed that the apparatus position can be adjustable, without drilling or threading on the site.

10.5.2. The conduits shall be fixed with clamps, or U hooks, these being threaded only at their extremities.

10.5.3. The fixtures or supports shall preferably be bolted and removable. They shall not be welded on piping elements, valves, tanks, etc. No welding shall be executed on already galvanized parts, to prevent oxidation. These shall enable easy disassembly of apparatus or conduits, and shall themselves be detachable.

10.5.4. Anchoring on concrete blocks, with the exception of light poles, shall be kept to a minimum. These shall have the minimum required dimensions and shall not protrude above levelled ground.

10.6. Connections

10.6.1. The CONTRACTOR shall rigorously conform to the principle that the connections must be effectuated from downstream to upstream so as to prevent any cable which has not been previously connected to the equipment it is supposed to supply, to be energized by occasional operation of the upstream breaking device.

10.6.2. Furthermore, the CONTRACTOR shall ensure, by all conventional means, the visible and explicit mechanical and electrical locking of the all apparatus which must not be under voltage during erection, and in any case before the electric power supply is available.

10.6.3. The connections shall be achieved in such a way that the terminal remains accessible, the wires being long enough and properly arranged in loops to ensure easy disconnection and prevent any stress on the cable.

10.6.4. The conductor sleeves or markers, as well as the terminal numbering shall be clearly visible and legible.



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10.6.5. The stranded conductors shall be connected by means of insulated fastened lugs, the fastening being effectuated with the particular crimping tools which are recommended by the manufacturer for the specific lugs in use.

10.6.6. In case when the installations are equipped with motors provided with space heating resistances (general case of main motors), the CONTRACTOR shall connect these resistances and supply them permanently under the appropriate voltage, this including all necessary means of protection and signalling.

10.7. Fuse Connector Junction Boxes

10.7.1. The connector block and fuses shall be provided, installed in the fuse connector junction box which shall be mounted by means of nuts and bolts over a 4 mm thick steel plate welded to the pole. The fixing arrangement with tapped and drilled holes shall be provided as required.

10.8. Fluorescent Lighting Fittings

10.8.1. The fluorescent lighting fittings on the surface of ceiling shall be installed with the back of the body flush with the ceiling surface and in manner so as to facilitate wiring. Nylon plugs and galvanized steel bolts or screws shall be used for fixing the light fixture to the ceiling.

10.9. Outdoor H.I.D Light Fixture Installation

10.9.1. The loose parts of the H.I.D light fixture received separately with the fixture shall be assembled as per Manufacturer's instructions. The fixture shall be mounted on the pole bracket as per Manufacturer's instructions. All nuts, bolts, washers and reducers shall be galvanized. The fixture shall be connected at provided terminals of the fixture. The earth continuity conductor shall be properly connected to the earth point provided in the fixture.

11. EARTHING, SUPPLEMENTARY BONDING & LIGHTNING PROTECTION

11.1. Earthing shall be carried out as per the CONTRACTOR's detailed drawings after COMPANY/CONSULTANT approval and fully in accordance with the latest standard regulations. Where deviations are necessary they shall be subject to the prior approval of COMPANY/CONSULTANT.

11.2. The earthing system consists of earth electrodes; tap connectors, earth connecting bars, earth continuity conductors and all accessories necessary for the satisfactory operation of the complete earthing system.

11.3. The earth system shall be installed to ensure that when any part of the earth system is disconnected for the purpose of carrying out periodic testing, an alternative path to earth is available.

11.4. The earth system shall be loop-connected, with cross sections as per detailed design requirements. The concept of the loops and the way they are connected shall be such that



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the apparatus can be easily removed without requiring a complex disconnection operation nor risking interruption of, or damage to the loop itself.

- 11.5. The resistance of the loop system with respect to the ground shall be less than the 1 ohm. If that does not have a resistance to ground of 1 ohm, it shall be augmented by driving additional electrodes at a suitable inter-distance until the required resistance is achieved.
 - 11.6. A particular grounding circuit, to separate ground pits shall collect the grounding of instrumentation, as well as their cable screens at one extremity, and in general, all electronic instrumentation with low signal levels, requiring particular care of noise rejection.
 - 11.7. Earth electrodes shall be *“Round Copper Rods”*. Rod type earth electrodes shall be *“20-mm diameter”* of fixed length required as per typical detail drawings. A concrete casing with concrete cover shall be installed to provide an easy access to the rod for inspection and test measurements.
 - 11.8. Connection of earth conductor to earth electrode shall be by proprietary clamps made so that they can be disconnected for testing.
 - 11.9. The ends of earth conductors shall be tinned after twisting so as to ensure the minimum contact resistance throughout its useful life.
 - 11.10. All metal Work used to enclose or contain current carrying conductors or components including the metal sheathing and armouring of cables shall be mechanically and electrically bonded together to form an efficient and effective earth return path for the maximum prospective earth fault current that may occur.
 - 11.11. Apparatus shall be connected to the earth system via cable armour, in addition to other means of earthing, except in the case of single core armoured cable.
 - 11.12. Where distribution boards, motor starter panels – motors, distribution boards, cable trays (ladder type), piping, steel Work, junction boxes, socket outlets, lighting fixtures, as well as frames, supports, pedestals, etc., are connected to the earth system or bonded together by means of earth conductors, the conductors shall be fitted with robust compression lugs and the equipment shall be provided with earth terminals, lugs or bosses made of flat bar.
 - 11.13. The parts on which they are connected shall be conveniently cleansed and surfaced. Equipment earth conductor shall not be smaller than 16 sq. mm PVC insulated copper conductor. Care shall be taken in the termination of the cable glands to ensure adequate earth continuity between Equipment and cable armour.
 - 11.14. The lightning protection system shall be installed accordingly as per material designed. Supplied by the CONTRACTOR during the detail engineering.
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Static Earthing and Bonding

- 11.15. Pipe lines, vessels, steel structures and Equipment not directly bonded to the electrical Equipment shall be bonded and earthed to the main earth system by one or combination of the following:
- a) Separate earth conductors.
 - b) Electrical continuous metal Work.
- 11.16. Any structure or other items within the plant boundary limits and outside the protection zone of neighbouring taller structure shall be directly connected to earth as close to the base as possible and shall also be connected to the main earth net-work.
- 11.17. In hazardous area, all vessels, steel structures and also services (i.e. pipe lines) that enter and leave the area shall be earthed by earth conductors. Static earth conductors shall not be sized less than 16-sq. mm.
- 11.18. The CONTRACTOR must check that effective bonding has been achieved by testing the resistance to earth at any point of the piping and steel structures to be less than one ohm.
- 11.19. All incoming services to the site area and to individual buildings shall be connected to earth and bonded at their points of entry to the earthing system, (i.e., water, gas, etc.).
- 11.20. Conductors shall be terminated at bus-bars (if required), electrical equipment and plant items by means of bolted connections.
- 11.21. Contact faces of connections shall be cleaned, wire brushed and lightly smeared with 'Copper-grease' or an approved equivalent. Brass set screws, nuts, plain washers and phosphor bronze single coil spring washers shall be used.
- 11.22. Tape conductors shall not be drilled for any purpose other than for bolted or riveted connections. The hole diameter shall not exceed one half the width of the tape or one quarter the width of a bus bar.
- 11.23. Connections between identical and different sizes of stranded copper PVC covered earthing cable shall be made using BICC'CEETAP' compression connectors or equal. The CONTRACTOR shall ensure that the connectors supplied, in accordance with the manufacturer's recommendations. Connections shall be greased "Copper-grease" (or approved equivalent) and taped with Green/Yellow coloured PVC self-adhesive tape as protection against corrosion.
- 11.24. Each PVC insulated earth copper conductors run above ground shall be fixed by means of non-corrodible saddles or clips, the spacing of which shall not exceed 600mm for horizontal
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runs or vertical surfaces and 1200mm for vertical runs and where horizontal runs are continuously supported.

11.25. Where earth conductors exit from trenches to run above grade, they shall be protected by kick pipes for a minimum height of 1150mm above grade level.

11.26. Particular attention shall be paid to the assembly of cable termination glands to ensure the maximum effectiveness of the earth continuity between equipment and the armor and/or metallic sheaths of cables.

12. INSTALLATION OF LOW VOLTAGE ELECTRIC MOTORS

12.1. Installation, connecting, testing and commissioning of all LV electric motors complete with placement, alignment, levelling, coupling, cabling, termination, connections, glanding, reducer, lugs, supports, nuts bolts, washers, shims etc. In other words complete installation of motors is required as per standard practices and codes.

13. INSTALLATION OF MOTOR LOCAL CONTROL STATIONS (LCS)

13.1. Installation, testing and commissioning of free standing field mounted motor local control stations/ skid-packages mounted motor local control stations (LCS) with ON/OFF push buttons, selector switches (auto/manual), emergency push button, stand, cable glands and shrouds sealing, G.I. Pipe. Complete in all respects. The supply and installation of steel stand, MS-channels, mounting supports, nuts, bolts, washers, etc. required for complete installation of motor local control station (LCS). Complete in all respects.

14. INSTALLATION OF CONDUIT AND ACCESSORIES**14.1. Steel and G.I. Conduit**

14.1.1. The minimum size of conduit shall be 20mm.

14.1.2. The use of solid or inspection elbows, bends or tees will not be permitted and 120° bends shall be limited to one between any two drawn-in boxes.

14.1.3. Conduit coupling joint shall not be used where conduits enter spout entry conduit boxes.

14.1.4. Conduit running joints shall not be used where conduit enter conduit boxes or spout entry boxes.

14.1.5. Equipment that is required to be removed for maintenance shall be provided with conduit unions in all conduits that enter such equipment.

14.1.6. The use of conduit nipples shall be avoided as far as practicable.

14.1.7. All conduits shall be cut square and reamed at the end. All conduit ends and the inside of conduits shall be clean and free from burrs.



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- 14.1.8. Where bushed spouts or tapped holes are not provided at conduit terminations the conduit shall be terminated in a flanged socket and a smooth bore brass hexagon bush, with a lead washer fitted between the flanged socket and the equipment or box.
- 14.1.9. All exposed threads and parts where the galvanizing has become damaged shall be thoroughly cleaned and painted with galvanized paint. The exposed conduit ends shall be capped to protect threads from being damaged before installing cables.
- 14.1.10. Repair painting shall take place before any making good on site or buildings is carried out.
- 14.1.11. The lids of all boxes, including motor terminal boxes, etc., which rely on machined face metal to metal joints shall be lightly smeared and greased to prevent corrosion and to ensure water tightness.
The entire conduit system shall be checked for continuity. Any obstruction found shall be removed without damaging the installation.
- 14.1.12. The conduit system shall be installed empty with a 16 SWG steel wire drawn through the conduits for pulling of cables.
- 14.1.13. Joints in underground conduits shall be avoided or reduced to the absolute minimum.
- 14.1.14. Where adjustable dies are used they shall be so adjusted that threads cut with them shall be the same depth as machine made threads.
- 14.1.15. The use of manufactured bends shall be avoided and instead smooth bends shall be provided by using approved type of bending tools.
- 14.1.16. Flexible steel conduits shall be installed at all points/locations where flexible connection is required, as directed by the COMPANY/CONSULTANT.
- 14.1.17. The flexible conduits, when used, shall be protected by external PVC sheath, resistant to oil damages.
- 14.1.18. GI pipes for underground installations shall be given bituminous paint coating and wrapped with suitable paper or cloth before installation.
- 14.2. Fixing Of Conduits And Fittings**
- 14.2.1. Conduits in process units and on steelwork shall be fixed with "U" bolt G.I type fixings.
- 14.2.2. Conduits in buildings shall be fixed with galvanized distance saddles.
- 14.2.3. Where a number of conduits follow a single route they may be fixed to mild steel brackets.
- 14.2.4. Conduits shall be supported on both vertical and horizontal runs as follows:
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- Conduit sizes 20mm and 25mm maximum spacing of fixing 1000mm.
- Conduit sizes larger than 25mm maximum spacing of fixing 1500mm.

14.2.5. All conduit boxes that support fittings shall be securely fixed.

14.2.6. All conduits shall be fixed 150mm before and after every right angle or off set.

14.2.7. All conduit fittings and equipment shall be fixed true and line able.

14.2.8. All conduit bends shall be made with an approved conduit bending machine or hickory. The radius of curvature of the inner edge of any bend shall not be less than the following table:

<u>Conduit Size</u>	<u>Radius</u>
20mm (3/4")	Not less than 130mm
25mm (1")	Not less than 150mm
32mm (1-1/4")	Not less than 200mm
38mm (1-1/2")	Not less than 255mm
50mm (2")	Not less than 305mm
70mm (2-1/2")	Not less than 380mm
82mm (3")	Not less than 460mm
100mm (4")	Not less than 610mm

14.2.9. Underground conduit stud-up or kick pipe through concrete envelope shall be extended a minimum of 150mm above grade and adequately braced to prevent shifting during concrete pouring work. The concrete envelope shall extend at least 76mm above grade.

14.2.10. Under floor conduit installation shall be at a minimum depth of 120mm from finished floor level.

14.2.11. The G.I. pipes/conduits shall be installed at a minimum depth of 1000mm measured from the top of the size to the finished road level.

14.3. Location of Conduits and Fittings

14.3.1. Before conduits are installed confirmation shall be obtained that the conduit may be installed in that position.

14.3.2. Particular attention shall be given to the location of conduits to prevent the infringement of headroom and access ways.

14.3.3. Conduits shall be located to avoid obstructions, furnaces, hot lines and other places of high temperature.

14.3.4. Conduit shall not be located closer than 150mm (6") where it runs parallel to or crosses hot surfaces.



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- 14.3.5. Underground conduit runs shall be kept to minimum in both number and length.
- 14.3.6. Conduits shall not be recessed in fair brickwork.
- 14.3.7. Not be located in the corners or other such locations and shall be positioned to avoid tight bends, bending and cable kinks.
- 14.3.8. Conduits shall not generally be installed having a greater length than 12,000mm (40 feet) between drawn in boxes.
- 14.3.9. Conduit entries shall wherever possible be located in the bottom of boxes and equipment etc.

15. STEELWORK & FIXINGS

- 15.1. Steel supports and brackets shall be properly fabricated and fitted in accordance with the power, lighting and earthing drawings. All rough edges shall be removed and bare steelwork shall have one coat or primer before installation. Painting shall be in accordance with the Project Painting Specifications.
 - 15.2. Adequate sizes of steelwork shall be used with a minimum thickness of 6mm.
 - 15.3. Welding to structures shall be the main fixing medium. The prior permission of COMPANY/CONSULTANT shall be obtained.
 - 15.4. Pre-cast concrete and structural steelwork may be drilled only when authorized by COMPANY/CONSULTANT, and only in the positions agreed.
 - 15.5. The use of cartridge fired studs will not be permitted.
 - 15.6. When the fixing of electrical equipment or materials to fireproofed structures is unavoidable, any brackets required for such fixings shall be installed before the fireproofing material is applied. Consideration must be given to the likelihood of heat conduction through such fixings causing damage to the fireproofed member and appropriate safeguarding action taken in agreement with COMPANY/CONSULTANT. Alternatively, and subject to the nature of the fireproofing, prefabricated clamping brackets may be employed subject to approval from COMPANY/CONSULTANT.
 - 15.7. Enclosures of an alloy construction shall be spaced off the supporting structures by a minimum of 3mm and mating surfaces of fixings protected by an approved anticorrosive coating.
 - 15.8. All fixings shall be adequate for their duty and shall have a rustproof finish e.g. cadmium plates or sheradised. Fiber wall plugs for wood or coach screws shall be used. Single coil spring washers shall be used for all bolted connections.
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15.9. Threads shall be ISO metric type.

16. HAZARDOUS AREA CLASSIFICATION

16.1. The CONTRACTOR shall take into consideration, when carrying out the works and supplying the equipment, the following requirements:

The electrical equipment installed in hazardous areas shall meet with the following classification and selection criteria.

- Areas where gases or combustible vapours may occur in normal operation. The equipment shall have adequate protection for these conditions. Equipment suitable for installation in Zone-1 shall be used.
- Areas where gases or combustible vapours may occur under abnormal circumstances. Equipment suitable for installation in Zone-2 and Zone-1 shall be used.

16.2. The CONTRACTOR shall refer the project reference document for selection of equipment w.r.t area classification as defined.

16.3. Plastic housings are not accepted for junction boxes, push-button stations, socket outlets, switches or plastic cable glands, in so far as they are connected to armoured cables metallic conduits.

17. CATHODIC PROTECTION SYSTEM

17.1. A Cathodic protection system shall be designed, supplied and installed by CONTRACTOR which shall be applied to underground pipeline etc.

17.2. The Cathodic protection shall be an impressed current system with auto control having provision of manual also.

17.3. Transformer rectifiers shall be oil immersed transformer with Selenium or SCR type rectifier rated 400/230 volts 3 phase, 50 Hz to be finalized during the detail engineering by the CONTRACTOR. Transformer rectifier shall be installed in non hazardous area, and of weather proof, outdoor use type suitable for the area to be installed.

17.4. The CONTRACTOR shall be responsible to submit all the Vendor/Supplier catalogues, technical details w.r.t selected transformer rectifier (TR) to COMPANY/CONSULTANT for review and approval before the procurement and installation.

17.5. Electric power to the transformer rectifier shall be supplied from the new SWG/MCC panels, and shall be confirmed during detail engineering By the CONTRACTOR and accordingly all the relevant document / drawings will be developed for COMPANY/CONSULTANT approval.

17.6. Cathodic protection equipment to be installed in hazardous area shall be suitable for the area where the equipment shall be installed as per IEC 60079.



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17.7. Objects of the cathodic protection system shall be insulated from the other structures and above ground pipes by insulation flanges, insulation sheet or equivalent in order to minimize the spilt current.

17.8. Soil investigation shall be carried out to determine the soil resistivity and corrosivity.

18. BUILDING ELECTRIFICATION SERVICES**18.1. Installation Instructions - General**

18.1.1. The scope of the CONTRACTOR shall include the procurement, installation, testing and commissioning of complete building electrification works for the **KPD Compression Project**. The CONTRACTOR shall provide complete building electrification services as per the project building electrification layouts (to be developed by the CONTRACTOR during the detailed engineering).

18.1.2. The CONTRACTOR shall provide the guarantee for the electrification works for the Plant. The guarantee shall cover a minimum period of 12 months after commissioning of the system and issuance of Completion Certificate.

18.1.3. The CONTRACTOR shall provide "Danger Boards" and "Shock Charts" wherever required to comply with the requirements of local Electricity Rules and according to normal practice.

18.1.4. The CONTRACTOR shall furnish all materials, tools and equipment required to install, connect, test and commission all electrical equipment specified herein, whether or not such equipment is furnished by him or others.

18.1.5. For any major departures from the working drawings that are deemed necessary by the CONTRACTOR due to site conditions, the CONTRACTOR shall submit the details and shall sought the COMPANY/CONSULTANT's approval before starting such works.

18.2. TESTING**FACTORY TESTS**

18.2.1. All routine tests on equipment shall be performed at the manufacturer's works in the presence of the COMPANY's /CONSULTANT's representative if so required. Type test certificates of equipment shall be submitted whenever required by the COMPANY/CONSULTANT. All test results shall be supplied in triplicate.

18.2.2. All costs related to inspection and testing at manufacturer works including those of the COMPANY's /CONSULTANT's representative shall be borne by the CONTRACTOR.

18.2.3. The witnessing of tests by the COMPANY's /CONSULTANT's representative shall not relieve the CONTRACTOR of his obligations under the Contract.



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FIELD TESTS

18.2.4. Upon completion of the installation, the CONTRACTOR shall perform field tests on all equipment, materials and systems. All tests shall be conducted in the presence of the COMPANY's /CONSULTANT's representative for the purpose of demonstrating equipment or system compliance with specifications.

18.2.5. All tests shall be made with proper regard for the protection of the equipment and the CONTRACTOR shall be responsible for adequate protection to all personnel during such tests.

18.2.6. The CONTRACTOR shall record test values of the tests made on all equipment. Three copies of all data shall be given to the COMPANY's/CONSULTANT's representative for record purpose. The witnessing of any tests by the COMPANY's /CONSULTANT's representative shall not relieve the CONTRACTOR of his obligations under the Contract.

INSULATION RESISTANCE TESTS

18.2.7. Insulation resistance tests shall be made on all electrical equipment by using a meggar of 500V for circuits up to 250 volts and 1000V for circuits above 250 volts and up to 500 volts. Before making connections at the ends of each cable run, the insulation resistance measurement test of each cable shall be made. If insulation resistance test readings are found to be less than the specified minimum, the cable shall be replaced and the new cable shall be tested accordingly.

18.2.8. All switchboards/distribution boards shall be given an insulation resistance measurement test after installation, but before any wiring is connected. Insulation tests shall be made between open contacts of circuit breakers, switches and between each phase and earth.

18.2.9. If the insulation resistance of the circuit under test is less than the specified value, the cause of the low reading shall be determined and removed. Corrective measures shall include dry-out procedure by means of heaters if equipment is found to contain moisture.

18.2.10. After all tests have been made, the equipment shall be tested and reconnected as required.

18.3. WIRES & CABLES

GENERAL

18.3.1. The CONTRACTOR shall furnish and install all wires and cables along with the accessories as specified herein, in Bill of Quantities and Drawings. Apart from the material specified, the CONTRACTOR shall provide, without any extra cost, the necessary materials for termination or fixing of wires and cables such as lugs, solder, supports, bushes etc. for a complete wiring installation. Miscellaneous materials, like filling compound, identification tags, markers and earthing strips shall be furnished for completion of works in accordance with the best



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engineering standards and practice. The wiring installation shall be carried out in strict accordance with the scheme, cable size and circuit details shown on the drawing s or as specified.

MATERIALS

18.3.2.The cable for underground / exposed on surface and concealed conduit-wiring system to light or power circuits shall be single/multicore, PVC insulated, having soft annealed stranded copper conductors. The voltage grade shall be 450/750 volts for lights and sockets circuit and for power circuits as specified. Flexible cord for connection of light shall be 3 cores PVC insulated PVC sheathed.

18.3.3.The minimum size of conductor shall be as following:

– Point to Point Wiring	:	1.5 mm ²
– Light and Power Circuits	:	2.5 mm ²
– Single Power Socket 15 Ampere	:	2.5 mm ²
– Power Socket 20 Ampere (AC Split Units)	:	6 mm ²
– Earth Continuity Conductor (ECC) for Lighting	:	1.5 mm ²
– Earth Continuity Conductor (ECC) for Power	:	2.5 mm ²

18.3.4.The cables shall be type of 2-core (1P+N) or 4-core (3P+N) with the following colour coding:

– Phase 1 (L1)	:	Red
– Phase 2 (L2)	:	Yellow
– Phase 3 (L3)	:	Blue
– Neutral	:	Black
– Earth Continuity Conductor (ECC)	:	Green/Yellow

18.3.5.The wires or cables shall be terminated at light points, switchboard, etc. such that the insulation is always led into the equipment to which connection is made. The cable entry hole in equipment shall be such as not to damage the cable. Inside the switchboards or control boards, the wires or cable shall be securely fixed in a neat arrangement and laced with cord. The wires of different phases shall preferably be bunched and locked separately. Identification tags or ferrules shall be provided at termination of wires in switchboards with respect to connected equipment for ease of installation and maintenance.

INSTALLATION

18.3.6.The wiring through exposed/or concealed conduit shall be started only after the conduit system is completely installed and all junction boxes, outlet boxes, switchboards, etc. have been fixed in proper position. For outdoor installation, where specified, the cables shall run directly underground, or in pipes as specified. The cables shall be pulled through conduit or pipes with care to prevent any damage to cables. To facilitate cable pulling, lubricant only as recommended by cable manufacturer may be used for decreasing friction. Under no



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circumstances oil or soap shall be used for cable pulling. Where several wires are to occupy the conduit or pipes, they shall be pulled along together with earth continuity conductor. In general, the wires shall not be bend to radius less than ten times the overall diameter of the wire, or greater if recommended by cable manufacturer. The CONTRACTOR shall furnish all installation material for installation, testing and commissioning of cable system.

18.4. PVC CONDUIT & PVC PIPE**PVC CONDUIT - GENERAL**

18.4.1. The conduit for lights, sockets and power circuit wiring (except for power distribution work) shall be P.V.C electrical conduits. The CONTRACTOR shall whenever required by the COMPANY's /CONSULTANT's representative, furnish test Certificates and guarantees from conduits manufacturer for the material supplied.

18.4.2. Manufactured smooth bends shall be used wherever conduits change direction. Bending conduits by heating or otherwise can be adopted provided that the recommendations of conduit manufacturers are strictly followed. After completion of conduit installation, the system shall be checked for any charged or twisted portion prior to the pulling of wire. The sharp 90-degree bends or tees shall not be allowed. All conduit accessories shall conform to same material specification as given above for conduit. The bends shall have enlarged ends to receive conduit without any reduction in the internal diameter at joints.

18.4.3. The round box for ceiling light point shall be of P.V.C having minimum dimensions of 60mm diameter and 63mm deep. The outlet box at wall light points shall be general-purpose type having minimum dimensions of 63mm diameter and 38 mm deep. Round junction boxes shall be provided with one piece PVC cover plate to be fixed to be the PVC box by means of brass screws. Pull boxes and inspection boxes shall be installed in conduit runs where required to limit the pulling of the cables or for inspection purposes. The pull boxes shall be square having minimum dimension of 100mm and 55mm deep. The minimum length of inspection boxes shall be not less than four times the cable manufacturers recommended bending radius of the cable. These dimensions are minimum only and the CONTRACTOR shall determine the exact size keeping in view of the ease of maintenance and installation. In general the use of pull boxes and installation boxes shall be avoided. The pull boxes and installation boxes shall be of 16 SWG galvanized sheet steel. Wherever installed, pull boxes and inspection boxes shall have a cover of 33mm thick ply-board with white Formica plate glued firmly to it. The faceplate shall be secured to the box by means of flat head brass screw. The drawings are diagrammatic and do not indicate the location of junction boxes, pull boxes or inspection boxes, which however shall be provided to suit the condition at site.



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18.4.4. The conduits shall be concealed in roof, wall, column etc., as required. The concealed conduits shall have a minimum of 25mm concrete cover, when concealed in R.C.C. works. The conduits in R.C.C. works shall be laid before pouring of concrete, and chases shall not be made in R.C.C. structure for conduits and accessories after pouring of concrete. The conduit shall be laid over the bottom reinforcement steel, and tied firmly to it. The conduit outlet boxes shall be held firmly to finish with sift of the slab or beam. At expansions joints flexible conduits or alternate arrangement shall be provided.

18.4.5. Where conduits have to be concealed in cement concrete work after concreting or in block masonry, chases shall be made with appropriate tools and of required depth. The conduit shall then be fixed firmly in the recess and covered after plastering. All chases for concealing conduits shall be carried out by the CONTRACTOR. The CONTRACTOR will be responsible for bringing back the general finish to the condition that it was before the cutting and chiselling.

18.4.6. The work of conduit installation and cutting in cement concrete work or brick work shall be coordinated with civil construction so as not to cause any undue hindrances and delays in progress. The CONTRACTOR shall obtain approval of the COMPANY/CONSULTANT for route etc. to suit the site conditions, before starting chasing and cutting. All junction boxes, outlet boxes, pull boxes etc. shall be installed concealed so as to finish with the surface.

INSTALLATION

18.4.7. The conduit shall be installed concealed in wall, column or ceiling or under floor or on surface or above the false ceiling or as stated on the drawings.

18.4.8. Conduits installed on surface (if required) shall be fixed by means of medium duty steel saddles and clamps. The clamps shall be installed at a distance of not more than 600mm.

18.4.9. At all joints PVC jointing solution must be used.

OTHER REQUIREMENTS OF CONDUITS SYSTEM

18.4.10. The termination of conduits is shown diagrammatically on the drawings. The exact final location of the termination shall be co-ordinated with the equipment to be installed. Conduit ends pointing upwards or downwards shall be properly plugged in order to prevent the entry of foreign materials. All openings through which concrete may leak shall be carefully plugged and boxes shall be suitably protected against, filling with concrete. At all termination of conduit, soft bushes shall be fixed to prevent sharp edges of conduit ends from cutting or damaging the wires or cables to be pulled through them. The entire conduit system shall be installed and tested before wiring is carried out. Any obstruction found shall be removed and the conduit be cleaned out before the installation of cable.



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18.4.11. Pull boxes and adaptable boxes shall be provided in conduit runs wherever required to facilitate pulling operation. The drawings are diagrammatic and do not indicate the position and spacing of pull boxes or adaptable boxes.

PVC PIPE

18.4.12. The PVC pipes shall be rigid conforming to the requirements of British Standards. All pipes shall be class-D, unless otherwise stated. Where pipe changes direction, manufactured smooth bends shall be used. The use of 90-degree bends and tees shall not be allowed. The bends shall conform to the same specification as for PVC pipes.

**18.5. WIRING ACCESSORIES
SWITCHES INDOOR TYPE**

Switches for controlling light points shall be single pole, rated for 6 amps, 230 volts A.C. The body of the switches shall be of Bakelite with white face plate suitable for flush mounting on a sheet steel outlet box.

Unless otherwise specified wherever switches control the light points, these shall be plate type gang switches installed on common outlet boxes.

SWITCH SOCKET OUTLETS

Switches socket units shall be 2 & 3-pin, 5 Amps & 13/15amp. 3-pin, 20Amp. 230 volts, A.C., molded type with switch and socket on white faceplate. The outlets shall be heavy-duty type suitable for mounting on sheet steel outlet box. The 3-pin 13/15 amps, sockets shall have shrouded live contacts and designed such that the earth pin of plug is engaged to socket earth before mating of live contacts.

OUTLET BOX

The outlet boxes for installation of switches push buttons and socket outlets shall be 16 SWG galvanized sheet steel have appropriate dimensions. The box shall have suitable arrangement for receiving the conduit, an earth shall be provided for connecting the earth wire.

WIRING ACCESSORIES INSTALLATION

The mounting heights of all wiring accessories fixtures are stated on the drawings. In case the mounting height is not mentioned, the instructions of the COMPANY's /CONSULTANT's representative shall be obtained before fixing.

Switches and switch sockets units shall be installed on 1.63mm (16 SWG) thick galvanized sheet steel box for surface mounting or recessed in wall. The fixing of plastic sheet on sheet steel box shall be by means of flat head galvanized screws sunk in the plastic plate so as to finish flush with the surface. The edges of the plastic plate shall be chamfered.



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19. IDENTIFICATION

- 19.1. All distribution boards and isolators shall be identified with circuit designations and source of incoming supply. Lighting switches on large installations shall also be identified.
- 19.2. Labels for indoor or weather protected areas shall be white-black (or red) – wire, laminated plastic with lettering engraved to show the middle layer. Identification and instructions shall be in black lettering. Warning or danger shall be in red.
- 19.3. Fixings shall be screws or rivets, adhesive methods are not permitted. Enclosures of Certified Apparatus in hazardous areas shall not be drilled. Labels shall be mounted alongside the equipment. Other enclosures may be drilled to affix labels subject to the prior approval of COMPANY/CONSULTANT, provided the degree of protection is maintained.

20. CARE OF EQUIPMENT

- 20.1. Equipment removed from covered storage or packaging may not necessarily be fully protected until installation has been completed. Conduit and gland entries and removable covers are particular examples of this and arrangements shall be made, and maintained, to ensure protection against the effects of local weather and construction environment.
 - 20.2. Particular attention shall be paid to protect and safeguard equipment and materials installed in outdoor locations and unfinished buildings. Such equipment is vulnerable to damage during plant construction. Covers which are temporarily removed during installation shall be reassembled correctly on completion of work and replaced when such work is suspended or otherwise left incomplete, even for short periods e.g. meal breaks. Similarly all cable entries shall be effectively sealed at all times. Unused conduit cable entries shall be permanently sealed by the insertion of stopper plugs.
 - 20.3. Machined flanges of flameproof equipment installed in exposed position shall be liberally treated with a coating of approved grease unless such equipment has been factory treated and the flanges left unbroken during erection procedure. Any grease seal, which has been broken during installation, or during testing and commissioning procedures, shall be re-established.
 - 20.4. Anti-condensation heaters shall be energized from the temporary construction supply until the permanent installation is energized. Isolation and warning labels shall be provided. COMPANY/CONSULTANT may require temporary heating facilities to be provided for other equipment. Such heaters as are needed shall be safe and adequate for the purpose, cause no risk of fire to adjacent materials and rigidly secured. Lamps shall not be allowed to be used as heaters.
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21. TESTING & INSPECTION

- 21.1. Inspection, testing and pre-commissioning & commissioning shall be carried out in accordance with a Field Testing Inspection and Pre-commissioning & Commissioning Specification to be issued by the CONTRACTOR. The specification shall be subject to approval by COMPANY/CONSULTANT.
- 21.2. Certificates of test shall be compiled, for each section of the installation. A master set of these documents shall be kept as the original of the *"Test Dossier"*. This dossier will bear the signatures of COMPANY's /CONSULTANT's representative witnessing the tests.
- 21.3. All tests shall be carried out by suitably qualified and experienced staff using recently calibrated test equipment provided by the CONTRACTOR.
- 21.4. Notice of testing shall be given in reasonable time (24 hours minimum) to allow the tests to be witnessed by COMPANY's /CONSULTANT's representative.

22. ASSOCIATED CIVIL WORKS

- 22.1. The expression 'Associated Civil Works' shall mean civil Works in relation to electrical Works to be carried out by the CONTRACTOR. The installation Works shall adhere to drawings prepared during detailed design phase giving details of all fixings, bases and other civil Work requirements. Following are some of the main Works to be carried out by the CONTRACTOR:
- Excavation / formation of trenches, etc., and the filling in of it properly after the cables are laid, including lying of sand and brick tiles.
 - Excavation for underground cable ducts and covering / back filling.
 - Construction of general earthing pits, lightning earthing pits etc.
 - Cutting and forming of chases, recesses, holes for conduits or pipes, or conduit or pipe fixings through walls, floors, ceilings, partitions, roofs, etc., and making them good.
 - Construction of equipment foundations and light poles, LCS, welding outlet.
- 22.2. All the civil work required for the aforementioned activities i.e. pole foundation, structure mounted equipments foundation, direct buried trenches, floor cuttings & reinstatement work is also covered in the CONTRACTOR scope even not mentioned in tender document. Cutting, Fitting, Repairing, patching or plastering and finishing of Work, shall be done by craftsmen skilled in their respective trades. When cutting is required, it shall be done in such a manner so as not to weaken structure, partitions or floors.

23. AS-BUILT DRAWINGS

- 23.1. During the progress of the installation work, the CONTRACTOR shall maintain a set of master drawings on which the CONTRACTOR shall record as-built changes to the design as the installation proceeds. These drawings shall also be used to record all changes agreed with COMPANY/CONSULTANT on site.
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- 23.2. On completion of the installation, inspection and testing procedures, the CONTRACTOR shall furnish to COMPANY/CONSULTANT, as-built issues of all contract drawings. One reproducible and two prints of each drawing will be required for the approval of COMPANY/CONSULTANT.