SECTION 1- LIGHTNING PROTECTION SYSTEM

PART 1 - GENERAL

1.1 RELATED WORK AND OBLIGATIONS

A. Examine all the other sections of the specifications for requirements which may affect work of this section.

B. Coordinate work with all other trades affecting or affected by activities of this section. Cooperate with such other trades to assure the steady progress of all operations under the Contract.

C. Waterproofing integrity restoration (to the satisfaction of the architect and the waterproofing specialist) affected by the works described above (including earthing, grounding and lightning protection earth electrodes, down conductors, bonding conductors….etc).

1.2 SEQUENCING AND SCHEDULING

Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes

1.3 SUMMARY

A. Description of work: Early streamer emission network, down conductors, earth termination network, bonding to prevent side flashing and accessories.

1.4 STANDARDS:

A. Work is to comply with NFC 17-102 edition 2011

1.5 GUARANTEES

A. Manufacturers shall provide their standard guarantees for work under this Section. However, such guarantees shall be in addition to and not in lieu of all other liabilities, which manufacturers and Contractors may have by law or by other, provisions of the Contract Documents.

B. All equipment and design shall be guaranteed against faulty materials and workmanship for 10 years.

1.6 QUALITY ASSURANCE

A. Manufacturer: Firm regularly engaged in the manufacture of equipment for lightning protection and where products have been in satisfactory use in Beirut/Lebanon for not less than 10 years.

B. Installer: Firm regularly engaged in the installation of equipment for lightning protection and where installations have been in satisfactory use for not less than 10 years.

1.7 SUBMITTALS:

A. Submit data for approval including manufacturer's illustrated catalogues with description and specification of component parts for Protective terminations, conductors, fasteners, testing joints (test links), earth rods, connectors, wall inserts and bolts and any accessories forming part of the lightning protective system.

1.8 SHOP AND CONSTRUCTION DRAWINGS:

A. Submit drawings for approval including but not limited to, the followings:
1. Exact location and routing of roof, antenna tower, down conductors with indication of sleeves and types of fixings.
2. Exact location of earth pits and routing of interconnecting ring
3. Typical details of jointing and bonding.

1.9 AS- BUILT DRAWINGS

A. Provide as-built drawings and indicate nature of soil, special earthing arrangements, date and particulars of salting if used, test conditions and results obtained.

1.10 MANUFACTURERS

A. Obtain equipment, manufactured specifically for lightning protection, from one of the following:

1. Helita (France)
2. Franklin (France)
3. Ingesco (Spain)
4. Wallis (UK)
5. Furse (UK)

PART 2 - PRODUCTS AND SYSTEMS

2.1 TECHNICAL REQUIREMENTS

A. LIGHTNING WITH PROTECTIVE ROD. Lightning protection based on the following principles: The lightning Protective Rods works when the lighting approaches the ground, a brush discharge is initiated at the lightning conductor, the Protective Rod will urge the brush discharge to propagate in the direction of the direction of the descending leader after a long transition phase. The Protective Rod initiation advance permits to reduce the required time for the formation and continuous propagation of the ascending discharge and brings thus a higher efficiency for the lightning capture.

B. EFFICIENT INITIATION ADVANCE. The Protective Rod emits a high voltage signal at a determined controlled frequency and amplitude, the effectiveness is guaranteed by the rapid formation and propagation of the upward leader, while reducing the development of space charges around the point.

C. ENERGY AUTONOMY. The Protective Rod is also self-contained. It draws its energy from the ambient electric field existing at the time of the storm (10 to 20 KV/m). The initiation advance starts up as soon as the ambient field exceeds a peak value which corresponds to the minimum lightning stroke risk.

D. INITIATION ADVANCE OF THE PROTECTIVE ROD. This advance is characterized by an early initiation of the continuously propagating upward leader. Test certificates shall be done according to NFC 17-102 values shall give a ΔT <100µs and a 60% margin has to be considered. The ΔT shall be 60 µs according to appendix C of NFC 17-102 and a protection level I (Δ=20 meters max) according to appendix B of NFC 17-102.

E. DOWN CONDUCTORS every down conductor (at least 2) is to have test link above ground for testing earth termination network, is to be protected against corrosion for 0.3 m above and below ground level, is to terminate in an earth electrode and is to be insulated with PVC or polyethylene (5 mm thick) from test link to electrode connection point.

F. EARTH TERMINATION NETWORK: earth electrodes are to be interconnected and buried with the top at least 1 m below ground surface and minimum 0.6 m from the foundations. All electrodes are to have resistance to earth (in ohms) not exceeding, tested with test link removed and before bonding to other services or other earth electrodes. Combined resistance to earth of whole network is not to exceed 5 ohms.

G. COMMON EARTHING: earth termination electrodes are to be interconnected in a ring around the structure and bonded to earth electrode of protective earthing system, forming a common earth ring of total resistance value to earth below the lower value of any of the two systems.

H. PROTECTIVE ROD: shall have a 3 meters minimum stainless steel mast to which additional stainless steel mast units could be attached. The height of the tip of the protective rod shall be minimum 5 meters higher than any other object of the project. The radius of protection Rp shall cover the whole project with the specified safety margin.

I. JOINTS AND INTERCONNECTIONS in earth termination network are to be exothermic welds except that down conductor is to be connected by a single or multi- conductor bolted U- connector clamp.

J. EARTH ELECTRODE is to comprise any of the following arrangements:

1. Deep driven earthing rod (3 m minimum total length, composed of several stacked earth rods), or where necessary, drilling of ground, insertion of rod and backfilling with soil conditioning agents such as Bentonite , Marconite or Terrafill.
2. Matrix arrangement of rods (where deep driving is impossible) coupled to one another by buried conductors, spaced at least equal to and not less than twice their driven depth, with total length not less than 9 m and minimum rod length 3 m

K. ISOLATION of every earth electrode for testing is to be possible.

2.2 MATERIALS AND COMPONENTS

A. The materials, of which protection systems are made, shall be resistant to corrosion or shall be acceptably protected against corrosion. No materials shall be used that form an electrolytic couple of such nature that will with the presence of moisture cause corrosion.

B. ROOF CONDUCTORS AND RING DOWN CONDUCTORS: bare, high conductivity, annealed copper strip, 25 x 3 mm (or 70mm2 if and where indicated on drawings).

C. OPERATION OF THE PROTECTIVE ROD The Protective Rod tip plays a triple role:

1. Collect the energy necessary to power the electrical device contained in the cylinder.
2. Emit the brush discharges created by the high-voltage pulses.
3. Capture the lightning current to convey it to the ground.

The metal disc is the upper part of the external air gap designed to convey the lightning current from the tip to the ground. The metal cylinder contains the electric device of the Protective Rod system that generates the brush discharges. The pole serves to fix the Protective Rod for installation. The connecting clamp must be fixed to it, together with the down conductor.

D. Rod: solid copper with roll formed threads at base, bronze nut, cast gun metal terminal base of appropriate thickness and low resistance, and any other accessories for rigidly mounting to surface.

E. EARTH ROD: unless otherwise indicated on the drawings to be 20 mm diameter, 2.4 meter long, high strength, low carbon steel core of high tensile strength (600 N/mm2), grade 43 A of BS 4360, with 99.99% pure electrolytic copper molecularly bonded into steel core, 0.25 mm minimum thickness. Driving head is to be high strength steel. Couplings are to be long length silicon bronze, grade CS101 of BS 2874, internally threaded. Threads are to be rolled onto rod to ensure uniform layers of copper and strength.

F. INSPECTION (EARTH) PIT: precast concrete construction, of dimensions shown on the Drawings, with heavy duty cover and brass plate engraved 'Earth Pit Below' inset in cover. One pit is to be provided for each earth rod.

G. TEST LINKS: two- bolt split- coupling, copper alloy, made to join two ends of down conductor specified. Plate indicating position and number of electrodes is to be fitted above each test link.

H. BONDING CONDUCTORS: high conductivity, bare annealed copper tape, 25x3.0 mm minimum dimensions, or 70 mm2 soft drawn stranded copper cable.

I. ACCESSORIES including supports, joints, fasteners, clamps, bonds, test links etc. are to be copper or copper alloy and specially manufactured for the purpose. Clamps and connectors are to be specifically designed and sized for clamping and connecting to the various shapes and surfaces of bonded metalwork. Bimetallic connectors are to be used between different materials. Galvanized or plated steel nails, screws and bolts will not be accepted on copper installations. Mast shall be stainless steel.

J. FLEXIBLE BONDING STRAPS: flexible annealed copper braid, 25x3.5 mm, suitable for bonding flat surfaces, cut to length required and with drilled flat terminals for bolted connections. Special bimetallic alloy terminals are to be provided for joining to aluminum conductive parts.

PART 3 - FIELD AND INSTALLATION WORK

3.1 INSTALLATION

A. SUPPORT ROOF AND DOWN CONDUCTORS using fasteners spaced at not more than 400 mm centers horizontally and vertically, and fixed by anchor bolts or lead inserts with machined screws.

B. BENDS IN CONDUCTORS are not to be less than 200 mm radius and are not to exceed 90 degree turn.

C. DOWN CONDUCTORS are to follow most direct path between air terminals and earth pit. Re- entrant loops are not permissible. Tight angle bends may be allowed where absolutely necessary at edge of roof, whereby length of loop in relation to distance between its start and end is kept below eight times. Direct path is to be through an air space in a non-combustible, non- metallic duct with net cross- section 15 times area of conductor.
At least two down-conductors shall be provided for each protective rod.

D. MECHANICAL PROTECTION OF DOWN CONDUCTORS: provide C-PVC pipes underground, starting 0.2 m below ground and to a height of 1.8 m above ground. Test link is to be positioned 2 m above ground.

E. BOND EXPOSED METAL PARTS OF STRUCTURE to lightning protective system if clearance between any element of lightning system and metal part is less 1800 mm or the distance allowed by the Standard, whichever is smaller.

F. INSPECTION (EARTH) PIT is to extend 150 mm below top of earth rod. Cover earth rod connector with suitable protective compound which can be easily removed for inspection. Connector is not to be covered with backfill material and is to remain clean.

3.2 TESTS ON SITE AND RECORDS

A. RESISTANCE TO EARTH of each termination electrode and the network and of the complete bonded installation is to be measured during the dry season and checked against specified resistance.

B. ELECTRICAL CONTINUITY of conductors, bonds etc. is to be checked.

C. RECORDS: submit the following:
1. Actual layout and specification of components of the system
2. Nature of soil and characteristics and any special earthing arrangement
3. Test conditions and results.

SECTION 2 -EARTHING SYSTEM

PART 1 - GENERAL

Electrical Work Generally is to be in accordance with the requirements of Section 260000 of the Specifications.

1.0 DESCRIPTION OF WORK:

A complete equipotential earthing system installation that provides an properly sized earth connection to every source of energy. The system also provides protective earthing and equipotential bonding to all building elements and systems to eliminate electrical hazards based on the TN-S earthing system arrangement. The earthing system includes but not limited to the connection of the following:

A. Electrical Power sources earthing systems (transformers and generators neutrals).

B. Main earthing terminals or bars in electrical rooms.

C. Generator(s) earthing terminals.

D. Mechanical plant rooms earthing terminals.

E. UPS rooms earthing terminals.

F. Low current rooms earthing terminals including server rooms and telecommunication rooms.

G. Exposed conductive parts of electrical equipment.

H. Extraneous conductive parts including but not limited to raised floor pedestals and false ceiling supports.

1.1 REGULATIONS AND STANDARDS:

Carry out work in accordance with the following:

A. IEC publications 364-3 and 364-4 Electrical installations in Buildings.

B. Latest edition of NFC 15-100 Regulations.

C. Information technology – Cabling installation – EN 50174-1,2,3

1.2 DEFINITIONS OF TERMS:

Definitions of terms used on the Drawings and in the Specification are as follows:

A. EARTH: conductive mass of the Earth whose electric potential at any point is conventionally taken as zero.

B. EARTH ELECTRODE: conductor or group of conductors in initial contact with, and providing electrical connection to, Earth (already provided in the building).

C. EXPOSED CONDUCTIVE PART: any part which can be readily touched and which is not a live part, but which may become live under fault conditions.

D. EXTRANEOUS CONDUCTIVE PART: any conductive part not forming part of the electrical installation such as structural metalwork of a building, metallic gas pipes, water pipes, heating tubes etc. And non-electrical apparatus electrically connected to them i.e. radiators, cooking ranges and metal sinks etc. And non-insulating floors and walls.

E. PROTECTIVE CONDUCTOR:

Conductor used for some measure of protection against electric shock and intended for connecting together any of the followings parts:

1. Exposed conductive parts.
2. Extraneous conductive parts.
3. Earth electrode (s) (already existing)
4. Main earthing terminal or bar (s).
5. Earthed point of the source (s).

F. ELECTRICALLY INDEPENDENT EARTH ELECTRODES:

Earth electrodes located at such distance from one another that maximum current likely to flow through one of them does not significantly affect the potential of the other (s). These apply to earth electrodes for electrical installation grounding, functional earth electrode and lightning protection earth electrodes.

G. MAIN EARTHING TERMINAL OR BAR:

The terminal or bar provided for the connection of protective conductors, including equipotential bonding and functional earthing conductors if any to the means of earthing.

H. EQUIPOTENTIAL BONDING:

Electrical connection to put exposed and extraneous conductive parts at a substantially equal potential

I. EARTHING CONDUCTOR:

Protective conductor connecting main earthing terminal or bar of an installation to earth electrode or to other means of earthing.

1.3 EQUIPMENT DATA:

Prior to ordering materials, submit data for approval including, but not limited to, manufacturer's catalogues for earth rods, connecting clamps, earthing conductors, protective conductors, bonding conductors, connectors and other accessories, exothermic welding kits and tools etc., and samples of samples conductors as requested.

1.4 SHOP AND CONSTRUCTION DRAWINGS:

Submit drawings for approval including, but not limited to, the following:

1. Cross sectional area of all earthing, protective and bonding conductors
2. Layout and details of earthing provisions at substations, generators room, switchgear, distribution panelboards etc., indicating fittings used, insulation, plates and marking, passage and routing of earthing conductors, conduit, sleeves, grooves, niches etc., giving sizes and dimensions of component parts.

1.5 APPROVED MANUFACTURERS: obtain materials from one of the following:

1. Erico – Cadweld (USA)
2. Copperweld (U.S.A.)
3. Furse (UK)
4. Wallis (UK)
5. Kingsmill (UK)

PART 2 - PRODUCTS AND SYSTEMS EARTHING SYSTEM

2.1 GENERAL REQUIREMENTS

A. COMPONENT PARTS of earthing system are to include the following:

1. Main earthing terminals or bars.
2. Earthing conductors.
3. Protective conductors.
4. Equipotential bonding conductors.
5. Functional earth electrode, for electronic equipment (if required on drawings).
6. Earth electrodes for the lightning protection system (if required on drawings).
7. Accessories and termination fittings, bonding, welding kits and other materials.

B. EARTH ELECTRODE is to consist of one or more earth rods, interconnected by buried earthing tape or cable, which is to have a total combined resistance value, during any season of the year and before interconnection to other earthed systems or earthing means, not exceeding 3 ohms (or less if required by local regulations) otherwise use additional earth rods. Distance between two rods is not to be less than twice the length of one rod driven depth. Alternatively, a bare copper conductor of section not less than **70mm^2** (or as indicated on drawings, whichever is greater) can be installed in a ring configuration (grounding loop), in the natural soil, not less than 0.6 meters below that natural soil's surface. The required resistance of the grounding loop shall be as indicated for earth rods system. Earth rods and grounding loop can be used in conjunction if required.

C. FUNCTIONAL EARTH ELECTRODE (if required on drawings) is to be provided separately from, but interconnected to general bus collecting all the earth conductors in the building and to other earth electrode(s) through a transient earth clamp. Functional earth electrodes are to be used for earthing electronic equipment (communication equipment, digital processors, computers etc.) as required by the particular Section of the Specification and recommendation of manufacturer. The required resistance of the functional earth electrode shall be as indicated for other earth electrodes systems above

D. ALTERNATIVE EARTH ELECTRODE: other types of earth electrode may be used, after written approval and if not in contradiction with the local codes, including:

1. Cast iron pipes with special surround material
2. Copper plate (s)
3. Tape mats (strips)

E. MAIN EARTHING BAR is to be provided at point of service entrance or main distribution room, and as described in the Specifications or shown on Drawings, to which all earthing conductors, protective conductors and bonding conductors are to be connected. Two insulated main earthing conductors are to be provided, one at each end of the bar, connected via testing joints to the earth electrode at two separate earth pits. Conductor is to be sized to carry maximum earth fault current of system at point of application with final conductor temperature not exceeding 200°C for at least 1 seconds. Main earthing conductors are to be minimum **70 mm^2** insulated copper conductors from main earth bar to the building earth bar (at building electrical room).

F. TESTING JOINTS (TEST LINKS) are to be provided, in an accessible position, on each main earthing conductor, between earthing terminal or bar earth electrode. A bus system shall allow the disconnection of the lightning earth cable from the other earth cable in order to provide a separate test for each earth.

G. PROTECTIVE CONDUCTORS are to be separate for each circuit. Where protective conductor is common to several circuits, cross-sectional area of protective conductor is to be the largest of the conductor sizes. Unless otherwise mentioned the selection of sizes is to be in accordance with IEC 364 or NFC 15-100 (whichever is greater).

H. PROTECTIVE CONDUCTORS are not to be formed by conduit, trunking, ducting or the like. Where armored cable is specified and armor is steel, it may be used as a protective conductor, if approved and if not otherwise shown on the Drawings.

I. CONTINUITY OF PROTECTIVE CONDUCTORS: series connection of protective conductor from one piece of equipment to another is not permitted. Extraneous and exposed conductive parts of equipment are not to be used as protective conductors, but are to be connected by bolted clamp type connectors and/ or brazing to continuous protective conductors which are to be insulated by molded materials.

J. EARTH FAULT LOOP IMPEDANCE: for final circuits supplying socket outlets, earth fault impedance at every socket outlet is to be such that disconnection of protective device on overcurrent occurs within 0.4 seconds, and for final circuits supplying only fixed equipment, earth fault loop impedance at every point of utilization is to be such that disconnection occurs within 5 seconds. Use appropriate tables and present same approval by the Engineer.

K. SUPPLEMENTARY EQUIPOTENTIAL BONDING: all extraneous conductive parts of the building such as metallic water pipes, drain pipes, other service pipes and ducting, metallic conduit and raceways, cable trays and cable armor are to be connected to nearest earthing terminals by equipotential bonding conductors. Cross-section of protective bonding conductor is not to be less than half of the protective conductor connected to respective earthing terminal, and minimum 6 mm^2.

L. MAIN EQUIPOTENTIAL BONDING: main incoming and outgoing water pipes and any other metallic service pipes are to be connected by main equipotential bonding conductors to main earth terminal or bar. Bonding connections are to be as short as practicable between point of entry/exit of services and main earthing bar. Where meters are installed, bonding is to be made on the premises side of the meter. Cross-sections of conductors are not to be less than half of the earthing conductors connected thereto, and minimum 6 mm^2.

M. IDENTIFICATION: connection of every earthing conductor to earthing electrode and every bonding conductor to extraneous conducting parts is to be labeled in accordance with the Regulations, as follows: SAFETY ELECTRICAL CONNECTION- DO NOT REMOVE.

N. IDENTIFICATION: protective and earthing conductors are to be identified by combination of green- and - yellow colors of insulation or by painting bar conductors with these colors, as approved.

O. IDENTIFICATION: source earthing conductor is to be identified along its entire length by continuous green/yellow insulation labeled ‘earthing’.

2.2 EARTHING OF MAIN DISTRIBUTION BOARDS, PANELBOARDS, LIGHTING INSTALLATIONS AND WIRING ACCESSORIES

A. MAIN EARTHING BAR is to be provided in an approved location and connected to earth network by insulated conductor (size as mentioned on drawings) via testing joints.

B. EARTHING BARS OF GENERATORS (chassis of generators and common/neutral point) AND ELECTRICAL ROOM to be connected by insulated earthing conductor, directly to main earthing bar. Common point / neutrals of generators and MV/LV transformers shall be connected by insulated earthing conductors to their respective earth electrode earthing bar which is connected to the main earthing bar (as per TN-S earthing system requirements).

C. DISTRIBUTION, LIGHTING AND POWER PANELBOARDS are to be connected by protective conductors run together with incoming feeder cable, connecting earth terminals in panelboards with respective main building earthing bar.

D. SOCKET OUTLETS are to be earthed by protective conductor looped around with the branch circuit and connected to earth terminal within socket outlet box and to which socket outlet is to be connected.

E. LIGHTING FIXTURES AND OTHER EXPOSED CONDUCTIVE PARTS of electrical installations, such as switches, heaters, air conditioning units etc. are to be connected by protective earth conductors to earthing terminals of respective panel boards.

2.3 UTILITY SUPPLY EARTHING (BY EDL)

A. MV/LV transformers neutral (STAR POINT) is to be connected by insulated earthing conductor through the neutral earthing link or device to the main transformers earthing bar connected to the earth electrode connected to the project's main earth electrode. Neutral earthing conductor size to be as mentioned on drawings. MV/LV transformers (chassis), MV switchgear and MV cables screens for the project shall be grounded as required by IEC 364 or NFC 15-100 (whichever is greater).

B. LIGHTNING ARRESTERS are to be directly connected to earthing terminal, following the shortest path.

2.4 GENERATOR PLANT EARTHING

A. GENERATOR NEUTRAL (STAR POINT) is to be connected by insulated earthing conductor through the neutral earthing link or device to the main generators earthing bar connected to the earth electrode connected to the project's main earth electrode. Neutral earthing conductor is to be suitably sized to carry maximum earth fault current for time it takes the system protection to operate with final conductor temperature not exceeding 160°C, as required by IEC 364 or NFC 15-100 (whichever is greater). Generators chassis shall be connected to the main earthing bar of the building by insulated earthing conductors.

B. GENERATOR EARTHING TERMINAL is to be connected to main generators earthing bar by insulated copper conductor of cross section as required on Drawings.

C. SWITCHGEAR (ATS) AND CONTROL GEAR: switchgear and control gear enclosures are to be connected by separate protective conductors to earthing bars.

D. EXTRANEOUS CONDUCTIVE PARTS including steel frames, battery racks, day-tank, pumps and piping are to be connected by bare copper earthing conductors to main earth bar in compliance with bonding regulations.

2.5 MECHANICAL PLANT, ELECTRICAL ROOMS AND FIXED MACHINERY

A. MAIN EARTHING BAR OR LOOP is to be conveniently located in mechanical plant rooms, and connected by earthing conductors to exposed conductive parts of motor control center at its earthing bar, and to motors, switches and other electrical equipment etc… at their earthing terminals, using 20 x 3mm bare copper strips or as required on drawings **to carry maximum earth fault current for 1 second with final conductor temperature not exceeding 200°C.** Conductors are to be securely fixed, recessed in floor grooves or niches, or fixed to walls by appropriate staples. Earth bar or loop is to be securely fixed to building wall with copper or brass saddles.

B. MAIN EARTHING BAR OR LOOP is to be connected at two extremely separate points to earth network, directly through two test joints by insulated earthing conductors, or connected to main earth bar by protective conductors.

C. MOTOR AND OTHER EQUIPMENT EARTH TERMINALS are to be connected also by protective earth conductors of each branch circuit to earth terminal/ bar at motor control center, panel or distribution unit.

2.6 SERVER ROOMS, TELECOM AND UPS ROOMS

A. MAIN EARTHING BAR OR LOOP is to be conveniently located in each IT and UPS room, and connected by earthing conductors to exposed conductive parts of cooling units, racks, cable trays and miscellaneous containment system, PDUs, panelboards, UPS, battery racks, raised floor pedestals, metallic pipes…etc at its earthing bar, and to other electrical equipment at their earthing terminals, using 25 x 3mm bare copper strips or as required to carry maximum earth fault current for 1 second with final conductor temperature not exceeding 200°C. Conductors are to be securely fixed, recessed in floor grooves or niches, or fixed to walls by appropriate staples. Earth bar or loop is to be securely fixed to building wall with copper or brass saddles.

B. MAIN EARTHING BAR OR LOOP is to be connected at two extremely separate points to earth network, directly through two test joints by insulated earthing conductors, or connected to main earth bar by protective conductors.

C. EQUIPMENT EARTH TERMINALS are to be connected also by protective earth conductors of each branch circuit to earth terminal/ bar at feeding panelboard, panel or distribution unit.

2.7 MATERIALS AND PRODUCTS

A. EARTH ROD: copper clad steel, 20 mm diameter, 2.4 m length (in soil, to be extended as required to reach earth pit at finished floor level), extendible as necessary (minimum 2) to obtain required earth resistance. Earth rod is to be complete with couplings, head and bolted connector of sufficient size, and number of bolted clamps to connect all cables terminated thereto.

B. BURIED EARTH CONDUCTORS: annealed copper conductors **70 mm2** cross-section (as indicated on drawings, whichever is greater).

C. TAPS MATS: where earth rods are not likely to be used, earth electrode is to consist of parallel and perpendicular copper strip, 2.4 m apart, welded together by exothermic welds to form a grid. Tape is to be 25x25 mm strip conductor.

D. EARTH PIT: pre-cast, square or circular section concrete hand-hole (minimum 450 mm internal diameter), with concrete cover, and extending to about 150 mm below top of earth rod. Earth pit is to be provided for each earth rod where connected to an earthing conductor. Cover is to have inset brass plate with inscription 'Earth pit-Do Not Remove.

E. EARTHING CONDUCTORS: insulated (green/yellow) or bare copper conductor as described in the Specification for the particular application.

F. TESTING JOINTS (TEST LINKS): copper or copper alloy, with bolted end connections, disconnectable by use of a tool, and suitably sized for earthing conductors or earth bar connection. Links are to be fixed to porcelain or other approved insulating supports. Contact surfaces are to be tinned.

G. PROTECTIVE CONDUCTORS: single core stranded annealed copper, PVC insulated cables, having rated insulation grade compatible with circuit protected, or to be a conductor forming parts of a multi-core cable, color coded.

H. MAIN EARTHING BAR: hard drawn copper, 125x10 mm (Height x Width) where formed into a closed loop, and 150x10 mm (Height x Width) where open ended. Earth bar is to be labeled Main Earth Bar and is to be drilled, for connection of conductors, at a spacing not less than 75 mm, and is to be supplied with copper alloy bolts, nuts and washers and wall mounting insulators.

I. PROTECTIVE BONDING CONDUCTORS: bare copper strip conductor, annealed stranded copper cable or flexible strap (flexible braid) of cross-sectional area as described in sub- section 1 hereof.

J. EARTHING ACCESSORIES: copper or copper alloy, purpose made, of approved design, compatible with points of connection, and of adequate cross- section and current carrying capacity. Connectors and clamps are to be bolted type. Bolts, nuts and washers are to be high quality phosphor bronze or copper silicon alloys.

PART 3 - FIELD AND INSTALLATION WORK

3.1 INSTALLATION

A. CONTINUITY: ensure that complete earthing system is electrically continuous and mechanically secure.

B. EARTHING CONDUCTORS are to be following shortest path between earth rods and main earthing terminals or bars, and are to run in PVC conduit (duct) fastened to building structure by approved supports and extending 0.2 m above level, and are to be protected against mechanical damage and corrosion.

C. PROTECTIVE CONDUCTORS: separate protective conductors, which are not part of a cable, are to be fixed on same support or drawn into same conduit as circuit conductors.

D. PROTECTIVE BONDING: remove any non-conductive paint, enamel or similar coating at threads, contact points and surfaces and ensure that bonding is made by fittings designed to make secure bonds.

E. PROTECTION AGAINST CORROSION: protect bolted connections against corrosion either by filling with Vaseline or coating with a special anti-corrosion compound and proper capping.

F. CONNECTIONS: earth connections are to be readily accessible. If inaccessible earth connection is permitted, approved exothermic welding or brazing technique is to be employed.

G. CONNECTIONS: where earth connections between dissimilar metals must be made, use bimetallic fittings and protect by coating with moisture resisting bituminous paint or compound, or by wrapping with protective tape to exclude moisture.

H. Waterproofing integrity restoration (to the satisfaction of the architect and the waterproofing specialist) affected by the works described above (including earthing, grounding and lightning protection earth electrodes, down conductors, bonding conductors….etc) shall be provided.

3.2 TESTS ON SITE AND RECORDS

A. COMBINED RESISTANCE of earth electrodes is to be measured during dry season and checked against specified resistance.

B. ELECTRICAL CONTINUITY of all earthing and protective conductors including main supplementary equipotential bonding conductors is to be checked.

C. EARTH FAULT LOOP IMPEDANCE of all circuits is to be measured and checked against calculated impedance figures.

D. OPERATION of residual current protective devices is to be checked.

E. RECORDS: submit the following:

1. Scaled drawings, as-installed, showing actual layout and specification of all components of earthing system
2. Nature of soil and any special earth arrangements etc.
3. Date and particulars of soil conditioning method and agents if used
4. Test conditions and results obtained.

SECTION 3- SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER & LOW CURRENT CIRCUITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 16010 of Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes field-mounted SPDs for low-voltage (120 to 600 V) power distribution and extra low voltage (low current) equipment.

1.3 DEFINITIONS

A. I nominal: Nominal discharge current.

B. MCOV: Maximum continuous operating voltage.

C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.

D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current- voltage characteristic.

E. OCPD: Overcurrent protective device.

F. SCCR: Short-circuit current rating.

G. SPD: Surge protective device.

H. VPR: Voltage protection rating.

1.4 TYPES

Furnish and install a complete internal lightning protection system including lightning & overvoltage arresters. As follows:

A. Lightning current arresters (Class I): For protection of installations against lightning current due to direct or close lightning strikes to be installed at main distribution panel(s)

B. Combined Surge arresters (Class I+II): For protection of equipment against distant combined lightning current and surge to be installed at main distribution panel(s)

C. Surge arresters (Class II): For protection of equipment against distant surge to be installed at secondary distribution panel(s)

D. Surge Arresters (Class III): For protection of equipment against the effects of induced magnetic fields & switching overvoltage to be installed as close as possible to the equipment to be protected

Class I, I+II, II arresters shall be energy coordinated with Class III arresters and terminal equipment to assure proper protection.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, I nominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For manufacturer's special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: For SPDs to include in maintenance manuals.

1.8 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

1.9 APPROVED MANUFACTURERS

A. DEHN (Germany)

B. J.PROPSTER (Germany)

C. Schneider Electric (France)

D. Siemens (Germany)

PART 2 - PRODUCTS

2.1 GENERAL SPD REQUIREMENTS

A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Comply with UL 1449.

D. MCOV of the SPD shall be the nominal system voltage.

E. EN 61643-11

F. IEC 61643-1/-11

All supplied equipment shall be approved and certified by a third party laboratory as KEMA, UL, VDE or GOST.

2.2 Lightning Current Arresters – Class I (B)

Lightning current arresters should be:

A. High energy, no leakage current, encapsulated, using non-exhausting creepage discharge spark gap.

B. Energy-coordinated with surge arresters, Class II and III without additional Decoupling coils as well as energy coordinated with terminal equipment

C. Low voltage protection level

D. Double terminals for all conductor connections as well as output multifunctional terminal for conductors and bus bars

E. Ready for TT,TN-S,TN-C installations with the following technical specifications:

- Type 1
- Continuous operating voltage 255V /50-60Hz
- Follow current extinguishing capability 2 KA
- Lightning Impulse Current (10/350 μs) 100KA
- Voltage protection level Up <4 KV
- Response Time <100ns
- Back Up fuse 125A serial connection
  250 A parallel connection
- Max Continuous operating voltage Uc=255 V

F. With built in remote signaling with full monitoring including N/PE arrester

G. Enclosure material Thermoplastic UL94-V0

H. Approved by KEMA

I. Where space saving inside MDB is required, Combined arrester with built in fuse shall be installed.

2.3 Combined Lightning Current and Surge Arrester – Class I+II (B+C)

Combined Lightning current and surge arresters should be:

A. High Energy, Encapsulated, Leakage-current with series connection of gas discharge tube and varistor.
B. Safe fixation and contact ensured by module locking mechanism.
C. Energy-coordinated with surge arresters, Class II and III without additional Decoupling coils as well as energy coordinated with terminal equipment

D. Low voltage protection level

E. Double terminals for all conductor connections as well as output multifunctional terminal for conductors and bus bars

F. Ready for TT ,TN-S,TC installations with the following technical specifications:

- Type 1+2
- Continuous operating voltage 255V/ 50-60Hz
- Nominal discharge current (8/20μs)/total In 100KA
- Max discharge current (8/20μs)/total Imax 120KA
- Lightning Impulse Current (10/350μs)/Iimp 100KA
- Voltage protection level Up <1.5KV
- Response Time <100ns
- Back Up fuse 125A serial connection
  250 A parallel connection

G. With built in remote signaling with full monitoring including N/PE arrester

H. Enclosure material Thermoplastic UL94-V0

I. Approved by KEMA

J. Combined Lightning current arresters shall be installed inside each main distribution panel(s) (MDB). TT installation configuration with N/PE arrester (3+1 circuit).

K. Where space saving inside MDB is required, Combined arrester with built in fuse shall be installed.

2.4 Overvoltage Arresters – Class II (C):

A. Class II (C) surge arresters: To be installed at the power secondary distribution panel (SDB) with the following specifications:

- Nominal Discharge current In = 30KA (8/20)
- Max Discharge current Imax = 60KA (8/20)
- Uc = 280V [L-N], 255V [N-PE]
- Voltage protection level at In Up < 1.25KV
- Voltage protection level [L-N] for 5 KA Up < 1KV
- Response time <100ns
- Operating State: Green / Red
- Degree of protection IP = 20
- Enclosure materials – red thermoplastic UL 94 V-0
- Max. mains-side over-current protection: 125A Gg/Gl

B. With built in remote signaling with full monitoring including N/PE arrester

C. Ready for installation in TT ,TN-S, TC installation without additional wiring includes Thermodynamic disconnection circuit for disconnecting in case of fault

D. Class II arrester should be KEMA approved.

E. Where space saving inside SDB is required, Class II arrester with built in fuse shall be installed.

2.5 Overvoltage Arresters – Class III (D):

A. Class III (D) arresters shall be installed within the equipment to be protected with the following specifications:

- Continuous operating voltage 255V AC / 50Hz
- Tested to DIN VDE 0110 part 1
- Nominal discharge current 2.5KA (L+N/PE), 5KA (L+N/PE)
- Voltage protection level Up < 1.1KV
- Response time <25 ns
- Approved by UL or KEMA
- With remote signaling capability

2.6 SPD for Data Network and Communication:

A. All data cables shall be protected with surge arresters with the following specifications:

- SPD Class: Type 3
- Maximum continuous operating voltage Uc: 48V DC
- Nominal Current IL: 100mA
- Nominal Discharge current (8/20µs) per line/PE In: 2.5KA
- Voltage protection level line-line for In Up: <110V
- Response time <1ns
- Transmission rate 1 Gbit/s
- DIN Rail mountable
- Test Standard: IEC 61643-21
- Approved / Certified by: Cat. 6 acc. to ISO/IEC 11801, GOST

2.7 SPD for SMATV and CCTV systems:

A. CCTV cameras and Digital video recorders should also be protected using surge arresters specifically design to protect CCTV cameras and with residual voltage inferior to the system immunity against surges.

B. Surge arresters shall be used to protect both power ,video signal or IP interface for IP cameras, and control cables of each camera whereas the video signal at each DVR input shall also be protected.

C. Antennas masts shall be bonded to external lightning protection system through isolating spark gaps

D. SMATV signal shall be protected with SPD with the following specifications:

- SPD Class: Type 3
- Maximum continuous operating voltage Uc: 65V
- Nominal Current IL: 4A
- Nominal Discharge current (8/20µs) per line/PE In: 1.5KA
- Voltage protection level line-line for In Up: <350V
- Response time <1ns
- Frequency range 1MHZ-2.15GHZ
- Wave Impedance 75 Ω
- Test Standard: IEC 61643-21

E. For IP cameras, SPD should have the following specifications:

- SPD Class: Type 3
- Maximum continuous operating voltage Uc: 60V
- Nominal Current IL: 500mA
- Nominal Discharge current (8/20µs) per line/PE In: 1.6KA
- Voltage protection level line-line for In Up: <40V
- Response time <1ns
- Transmission rate 1 Gbit/s
- DIN Rail mountable
- Test Standard: IEC 61643-21

2.8 SPD for PABX System:

A. Telephone lines shall be protected also with surge arresters designed as terminal block with insulation displacement technology (soldering, screwing and strip-free connection technology)

B. Arresters with only Gas discharge tubes are not accepted.

C. Arresters shall have the following specifications:

- Variable protection for 1 to 10 pairs in LSA systems
- Modular system of lightning current and surge arresters
- Max continuous operating voltage Uc:180V

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with IEC 60364.

B. Install an OCPD or disconnect as required to comply with IEC standard.

C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

D. Use crimped connectors and splices only. Wire nuts are unacceptable.

E. Wiring:

1. Power Wiring: Comply with wiring methods in Section 16120 "Conductors and Cables."
2. Controls: Comply with wiring methods in Section 16120 "Conductors and Cables."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

1. Compare equipment nameplate data for compliance with Drawings and Specification
2. Inspect anchorage, alignment, grounding, and clearances.
3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. An SPD will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.3 STARTUP SERVICE

A. Complete startup checks according to manufacturer's written instructions.

B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.

C. Energize SPDs after power system has been energized, stabilized, and tested.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to operate and maintain SPD.