This section of the specification describes and specifies requirements for the supply, delivery, installation, testing, commissioning, handing over in approved working order and maintenance thereof during the Defects Liability Period of the whole lightning protection system in accordance with the Specification, Supplementary Notes, Bills of Quantities, Conditions of Contracts, Drawing etc.

The lightning protection system shall include air termination network, down conductors, joints and bonds, testing joints, lightning flash counter, earth terminations, earth electrodes and other accessories incidental to the completion of the whole system as specified in the Drawings and/or Bills of Quantities.

Generally, methods and materials used for the construction and installation of the lightning protection system shall comply with BS 6651.

Air termination network shall consist of a network of vertical and horizontal conductors generally as shown in the Drawings. All salient points of the structure shall be incorporated in the air termination network. All metallic projections, chimneys, ducts, gutters, vent pipes, guard rails, aerial masts, etc. on or above the main surface of the roof of the structure whether shown in the Drawings or not shall be bonded to and form part of the air termination network. Air terminals or vertical finials shall be provided if specified in the Drawings and/or Bills of Quantities.

Unless otherwise specified, air termination network other than the air terminals or vertical finials shall be of 25mm x 3mm annealed copper tape. The method and nature of the fixing shall be simple, solid and permanent. The air termination network shall be secured to the structure by means of naval brass purpose made fixings with base phosphor bronze screws at the intervals not exceeding 500mm. Purpose made supports for securing the air termination network onto the roof tiles and ridge tiles shall be used. Bonding clamps shall be of gun-metal and purpose made.

In the case of metal cladding roof, the air termination network shall be secured to the metal roof structures by means of non-metallic purpose made fixings and supports of UV stabilised outdoor grade polypropylene material. Intervals between fixings shall not exceed 300mm.

Air terminals or vertical finials shall be of rounded end and made of copper. Unless specified otherwise in the Drawings and/or Bills of Quantities, they shall be of 300mm in length and 16mm diameter with lock nut. The base for supporting the air terminal or vertical finial on the flat surface or ridges shall be of gunmetal and purposed made.

If portions of the structure vary considerably in heights, any necessary air termination network of the lower portions shall, in addition to their own down conductors, be bonded to the down conductors of the taller portions.

Down conductors shall be 25mm x 3mm bare annealed copper tapes installed around the outside walls of the structure. No down conductors shall be routed inside the service ducts.

The down conductor shall be installed in such a way that its path is as direct as possible between air termination network and earth termination. It shall be as straight as possible along the shortest path without sharp bends or upward sections. They shall be securely fixed at intervals not exceeding 500mm by means of Naval Brass fixings with base phosphor bronze screws.

The bend radii shall not be less than 200mm. Deep re-entrant loops, routing round parapet or cornices shall be avoided. However, a maximum height increase of 400mm is permissible for passing over a parapet wall with a slope of 45^0 or less. All wall or other building penetrations shall be made in a manner to prevent the ingress of water/water moisture and PVC sleeves shall be provided.

Unless otherwise as shown in the Drawings and/or Bills of Quantities, the number of down conductors is one for each 20 metres or part thereof the perimeter at roof level or ground level, whichever is the greater. Structures over 20 metres high shall have one per 10 metre or part thereof. Where more than one down conductor is used, the down conductors shall be arranged evenly and distributed around the outside walls of the structure.

All exposed down conductors shall be painted with the decorative colour paint of the same colour for the wall finishes.

The lightning protection system should have as few joints as possible.

Joints and bonds shall be made mechanically and electrically effective by means of purpose made copper clamps or by welding, soldering or brazing. Contact surfaces shall first be cleaned then inhibited from oxidation with a suitable non-corrosive compound. With overlapping joints, the length of the overlap shall not be less than 20mm.

Each down conductor shall be provided with a testing joint along the route of the down conductor. The testing joints shall be of purpose made copper clamps. Unless otherwise specified, each testing joint shall be installed at 2500mm above the ground level.

All fixings, clamps and supports for the air termination network and down conductors of the lightning protection system shall be purpose made for use in the installation. Unless otherwise specified elsewhere, they shall be of copper, naval brass or gunmetal.

The Electrical Contractor is required to submit installation methods and samples for fixings, clamps and supports for the approval of the S.O.'s Representative before installation.

An earth termination shall be connected to each down conductor. Earth termination shall be by 25mm x 3mm annealed copper tapes connecting the down conductor at the testing joint to the earth electrodes. The connection of the down conductor to the earth electrode of the earth termination shall be soundly made by the use of plumbed joints, either by brazing using zinc-free material with a melting point of at least 600 ^{0}C or by exothermic welding or by cold pressure welding. The portion of the earth termination between testing joint and ground shall be enclosed in PVC casing of suitable size.

All earth terminations shall be inter-connected by 25mm x 3mm annealed copper tapes to form earth termination network. The copper tapes shall be identified by permanent labels legibly marked with words "Lightning Protection Earth – Do Not Remove" permanently fixed at 1000mm intervals. The connection of two copper tapes shall be soundly made by the use of plumbed joints, either by brazing using zinc-free material with a melting point of at least 600 ^{0}C or by exothermic welding.

Each earth termination connected to the down conductor shall have a resistance to earth not exceeding the 10 Ohms. The whole of the lightning protective system shall have a combined resistance to earth not exceeding 10 Ohms.

Bonding conductor of 70 mm^2 PVC insulated green/yellow twin-coloured cable shall be provided for connection between the earth termination for the lightning protection system at the testing joint and the main earthing bar for the electrical installation.

Earth electrode shall be of copper-jacketed steel core rods with 16mm diameter and supplied in 1500mm length and shall have provision for screw coupling with another standard length. The copper jacket of 99.9 % purity electrolytic copper shall be of minimum radial thickness 0.25mm and shall be molecularly bonded to the steel core to ensure that the copper jacket and steel core are not separable. Each earth electrodes shall be driven 3000mm in depth.

Where the desired earth resistance value cannot be achieved after the first earth electrode have been driven, sufficient number of earth electrodes in parallel shall be installed outside the resistance area until required value is reached. Mutual separation between two earth electrodes shall be more than the driven depth of the earth electrode but less than twice the driven depth. Interconnection between different earth electrodes shall be by means of 25mm x 3mm annealed copper tape.

The connection of the annealed copper tape to the earth electrode shall be soundly made by the use of plumbed joints, either by brazing using zinc-free material with a melting point of at least 600 ^{0}C or by exothermic welding or by cold pressure welding.

Each earth electrode shall be provided with heavy-duty type inspection chamber with removable cover. The compressive strength of the inspection chamber and cover shall be minimum 6 N/mm^2. Lifting hook shall be provided in the cover.

Each earth electrode shall be identified by permanent label legibly marked with words "Lightning Protection Earth – Do Not Remove" permanently fixed at the point of connection of every down conductor to an earth termination and at every earth electrodes.

Where lightning flash counter is specified in the Drawing and/or Bills of Quantities, the counter shall be of outdoor weather proof type; and of the type that is triggered whenever it encounters a 1.5 kA impulse current in 1.5 microseconds duration. The counter shall record up to minimum 9,999 lightning strikes. The counter shall be installed on the most direct down conductor above the testing joint or any location indicated in the Drawing and, in any case, at the height of about 2000mm above ground.

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10.1 TEST AND CALIBRATION OF MEASURING AND TEST INSTRUMENTS

All measuring and test instruments used for testing of the lightning protection system installations shall be regularly tested and calibrated by the manufacturers or test and calibration laboratories for their functionality and accuracy. Basic measurement accuracy for these instruments shall be within 5 %. In the case of analogue instruments, a basis accuracy of 2 % of full-scale deflection shall be provided. Test and Calibration Reports or Certificates for the measuring and test instruments issued by the test and calibration laboratory shall be valid for two years from the date of issuance. The instruments and their Test and Calibration Reports or Certificates shall be submitted to S.O.'s Representative for verification two weeks before testing of the electrical installation being carried out. No test on the electrical installation shall be carried out without prior approval of the S.O.'s Representative.

Notwithstanding the validity of the aforesaid Reports or Certificates the measuring and test instruments shall be re-calibrated if so required by the S.O.'s Representative after any mechanical or electrical mishandling. Fee required for the testing and calibrating of the measuring and test instruments is deemed to be included in the Contract.

10.2 TEST AND TEST CERTIFICATES

After the installation work has been completed and before Certificate of Practical Completion is issued, the whole lightning protection system electrical installation covered under this part of the Contract shall be tested in accordance with BS 6651 and any other tests deem necessary by the S.O.'s Representative. In the event the installation fails to pass any of these tests, the Electrical Contractor shall take such measures as are necessary to remedy the defects and the installation shall not be considered as completed until all such tests have been passed.

The tests to be carried out by the Electrical Contractor shall consist of the following tests as a minimum requirement: -

(a) Continuity of air termination network.

(b) Continuity of air termination network and the down conductors.

(c) Continuity of the down conductor and earth termination.

(d) Continuity of earth termination network.

(e) Continuity of earth termination and the main earthing bar for the electrical installation

(f) Earth electrode resistance.

(g) Earth termination resistance.

Fee required for the tests as described above is deemed to be included in the Contract.

The S.O.'s Representative reserves the right to be present at all tests and the Electrical Contractor shall give at least one-week notice in writing to the S.O.'s Representative for this purpose. In any case, no test shall be carried out without prior approval of the S.O.'s Representative. Copies of all the test certificates together with as-installed Drawings properly bound and titled shall be submitted to the S.O.'s Representative within one week after the completion of the testing.

During the Defects Liability Period, the Electrical Contractor shall be responsible for the service and maintenance work for the complete installation. All works shall be carried out by the competent person. All labour, material, tools and parts necessary to rectify the defect due to manufacturing/installation faults shall be supplied/executed at the Electrical Contractor's cost.

The service and maintenance to be performed and defects to be rectified and making good shall include but not limited to the following: -

(a) Replacing or making good all lightning flash counters that do not meet the manufacturer’s guarantees and warranties.

(b) Replacing and making good all loose joints and terminations, all mechanical support linkage, earth electrode chambers and covers, etc.

(c) Making good any damage to roads, buildings, drains, cables, pipes, concrete areas, paved areas etc. which had not been properly made good arising out of his work.

(d) All other works as deemed necessary by the S.O.'s Representative.

All works shall be carried out as soon as the Electrical Contractor is being informed by the S.O.'s Representative or the occupant and shall be completed within a reasonable time except under emergency situation as stipulated in the Supplementary Conditions for Electrical Work. If the Electrical Contractor fails to comply with the above requirements, the S.O.'s Representative reserves the right to engage another party to carry out the work, in which case, the Electrical Contractor shall be responsible for all the expenses incurred.

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12.1 SHOP DRAWINGS

Two sets of prints of shop drawings for construction and/or installation shall be submitted to the S.O.'s Representative for approval. The Electrical Contractor shall prepare and submit shop drawings for the whole work or parts of the work at least two weeks before the work begins. If the shop drawings submitted are not acceptable by the S.O.'s Representative, the Electrical Contractor shall amend and re-submit the shop drawings within two weeks from the date of return of the shop drawings. The shop drawings shall include and show the following:

(a) The dimensioned general arrangements, layouts, positions and routes of air termination network, down conductors, earth terminations and all others necessary for the complete lightning protection system installation as specified in the Drawings and/or Bills of Quantities;

(b) Elevations views of the lightning protection system;

(c) The dimensioned general arrangements, layouts, positions and routes of bonding conductors;

(d) The dimensioned general arrangements, layouts, positions and routes of earth terminations and their earth electrodes.

The cost of all these shop drawings, whether or not provided in the Bills of Quantities, is deemed to be included in the Contract.

12.2 AS-INSTALLED DRAWINGS, MANUALS AND TOOLS

Within three calendar months after the practical completion of the project, one set of true to scale negative (110/115 gm/sq.m, ISO AO or A1 size) and four sets of prints for each of the following drawings and the approved shop drawings shall be submitted: -

(a) Site plan;

(b) Schematic Wiring Diagram and Layout Plans;

(c) Elevations views of the lightning protection system;

(d) Layout plans of conductor routes and earthing points with reference to easily recognisable buildings and structures.

These drawings shall be properly stenciled and shall have at the lower right hand corner the Electrical Contractor's name and address, date of commissioning, scale, drawing number (the drawing number to be obtained from the S.O.'s Representative), tittle and following particulars: -

JABATAN KERJA RAYA
CAWANGAN KEJURUTERAAN ELEKTRIK
CONTRACT NO.:
TENDER NO.:

If the drawings submitted are not acceptable by the S.O.'s Representative, the Electrical Contractor shall amend and re-submit the drawings within two weeks from the date of return of the drawings.

If required and specified elsewhere, in addition to the aforesaid negatives and prints, as-installed drawings shall be stored in electronic media or any other media as specified. For electronic media they shall be either in floppy disks format or CD rewritable (CD-RW) optical disks format as specified which can be easily retrieved by computer. The software programme shall be AutoCAD of latest release. Two sets or copies in either format as specified appropriately titled and stored in container or casing shall be submitted.

In addition, four sets of the following manuals and documents for lightning flash counters and other important equipment shall be supplied: -

(a) Installation manual;

(b) Operation manual;

(c) Service and Maintenance Manual;

(d) Parts List;

(e) Product Data and catalogue;

(f) Product Test Certificates;

Each of the above sets of prints together with the manuals shall be in a stiff cover ring file.

Special tools required for the operation, service and maintenance of lightning flash counters and other equipment shall also be provided.

The cost of all these prints, manuals, tools etc. is deemed to be included in the Contract.