SPECIFICATION FOR LOW VOLTAGE INTERNAL ELECTRICAL INSTALLATION (L-S1)

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CAWANGAN KEJURUTERAAN ELEKTRIK

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1.0.1 This section of the Specification describes and specifies requirements for the supply, delivery, installation, testing, commissioning, handing over in approved working order and maintenance during the Defects Liability Period of the whole electrical installation in accordance with the Specification, Supplementary Notes, Bill of Quantities, Conditions of Contract, Drawings etc.

1.0.2 Unless specified elsewhere, all equipment, switchgears, apparatus, appliances and accessories for low voltage electrical installation shall be rated for operation on a 230/400V (within the tolerance as defined in MS IEC 60038; 230/400V, +10%, -6%), 3 phase, 4 wire, 50Hz. system with solidly earthed neutral.

1.0.3 All standards shall conform to the latest MS, MS IEC, IEC, BS EN, BS and/or EN standard.

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2.0 SWITCHBOARDS

2.1 TYPES OF SWITCHBOARD

2.1.1 The types of switchboard shall be as specified in the Bill of Quantities and/or Drawings and shall be of the following types: -

2.1.1.1 Self-contained, floor mounted, flush fronted, metalclad cubicle type suitable for front and rear access;

2.1.1.2 Self-contained, floor mounted, flush fronted, metalclad cubicle type suitable for front access;

2.1.1.3 Wall mounted metalclad type suitable for front access.

2.1.2 The switchboards shall house their air circuit breakers, moulded case circuit breakers, fuse switches, switch fuses, isolators, contactors, busbars, meters, protective relays, selector switches, indicating lamps, current transformers, cable terminating boxes, cable glands, anti-condensation heaters complete with automatic thermostats and isolators and all other necessary items of equipment whether specified hereinafter or in the Drawings or not, suitable for operation on a 230/400V, 3 phase, 4 wire, 50Hz. system with solidly earthed neutral. Unless otherwise specified elsewhere, the switchboards shall be capable of withstanding fault condition of not less than 50kA at 400V for 1 second as defined in MS IEC 60439-1. The switchboards shall comply with MS IEC 60439-1 and the degree of protection shall be IP41 in accordance to MS IEC 60529.

2.1.3 Outdoor switchboards shall also comply with MS IEC 60439-5 with protection degree of IP54 in accordance to MS IEC 60529.

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2.1.4 Type testing for switchboard as per categorization shall be as per Table 2A below:

Category	Current Rating	Registration & Type Test Report
I	I ≤ 600A	Suruhanjaya Tenaga
II	600A < I ≤ 2000A	Suruhanjaya Tenaga & Partial Type Test in accordance with MS IEC 60439-1 (i) Short Circuit Test (Clause:8.2.3) (ii) Temperature Rise Test (Clause:8.2.1)
III	I > 2000A	Suruhanjaya Tenaga & Full Type Test in accordance with MS IEC 60439-1

Table 2A : Type testing for switchboard as per categorization

2.1.5 Routine tests on the switchboard shall be carried out before delivery to site. The main circuits and the auxiliary circuits shall be tested to verify dielectric properties with power-frequency test voltage of 2500V*ac* for 1 minute and insulation resistance under test voltage of 1000V. Routine tests shall include inspection and checking of wiring, electrical continuity of the protective circuits, connections and effectiveness of mechanical actuating elements and interlock. Test Results or Certificate duly certified by Competent Person as in Electricity Regulations 1994 shall be issued for every switchboard supplied and installed.

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2.2 ENCLOSURES

2.2.1 SELF-CONTAINED FLOOR MOUNTED CUBICLE SWITCHBOARDS

2.2.1.1 The framework of the switchboard shall be fabricated from rolled steel sections of thickness not less than 2.5mm and shall be self-supporting when assembled, uniform in height and depth from front to back. The rigid construction shall be designed to withstand without any sag, deformation or warping, the loads likely to be experienced during normal operating, maintenance or maximum fault condition.

2.2.1.2 The front shall be provided with covers/doors of box formation. The rear shall be provided with hinged removable doors of box formation. The rear doors shall be of double-leaf type with rebated edges and each leaf should preferably not be wider than 450mm. Each leaf of door shall have 2 pairs of approved hinges. The door shall be fitted with approved type of surface-mounted espagnolette or cremone bolts complete with approved locking device operated by a satin chrome lever handle at the centre fixing. The top and sides shall be of removable panels.

2.2.1.3 Cover plates with openings for cable entry shall be provided at the base of the switchboard. All panels, covers and doors shall be fabricated from sheet steel of thickness not less than 2.0mm and so constructed as to provide a clear, flush and pleasing appearance. The panels, covers and front doors shall be secured to the enclosure by means of chromed type of screws with cylindrical knurled head complete with retaining clips. Welded cross struts shall not be used.

2.2.1.4 The switchboard shall be dust and vermin proof. All covers and doors shall be provided with grommets and dust seals to exclude dust and dirt. Louvres or ventilation vent with filter shall be provided at the sides and back for adequate ventilation. Precaution shall be taken to prevent overheating due to hysteresis and eddy current using non ferrous plate (for single core cable). All edges shall be rounded. Serrated star washers shall be fitted to ensure satisfactory earthing of the front cover.

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2.2.1.5 Unless otherwise specified in the drawings and/or bill of quantities, the switchboards shall be of Form 2b and comply with MS IEC 60439-1. The busbars shall be separated from the switchgears/functional units and the incoming and outgoing terminals. The form of separation shall be achieved by metallic or non-metallic rigid barriers/partitions. All switchgears shall be mounted so as to give adequate clearance for cable and busbar connections.

2.2.1.6 Switchgears shall be mounted on insulation runners where connected to busbars and on steel supports where cable connection are made. The insulation runners shall be of minimum 10mm thickness and mounted on steel support or back panel of the enclosure whichever is more appropriate.

2.2.1.7 Cables connection between the busbars and the switchgears shall be neatly arranged and mounted on cable runner. The terminals of the switchgears for external cable connections shall be at least 200mm above the base of the switchboards and, moreover, so placed that the cables can be easily connected to them. Withdrawable type of switchgears shall be mounted on the framework assembly, including the runner rails and fixed rear isolation contacts, which shall be supplied as a part of the switchgear assembly. Each withdrawable switchgear shall be housed in its own compartment with rear connected busbars.

2.2.1.8 All indicating instrument which need to be read by the operator shall not be located higher than 2m above the base of the switchboard. All operating devices such as handle, push buttons, etc., shall be located at such a height that they can easily be operated, and in general, the centerline shall not be higher than 2m above the base of the switchboard. In the case where building automation devices, transducers and relays are provided, they shall be separately housed in a compartment of the section of the switchboard. All wiring from the devices, transducers and relays shall be neatly arranged and connected to the terminal blocks with removal links mounted on rail. Terminals shall be identified and labelled in accordance with IEC 60445.

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2.2.1.9 Where surge protective device is specified, the device and its associate equipment shall be totally compartmentalized with clear transparent cover at immediate lower subsection where the incoming switchgear is connected. A lockable tool compartment with keys and opening handle shall be provided at the lowest subsection of the switchboard. The switchboard shall undergo de-rusting treatment, anti-rust treatment with the exterior finished with epoxy dry-powder and oven baked semi-gloss beige colour and interior finished matt white. The switchboard shall be bolted to mild steel channel base or over concrete trench. The channel shall be anti-rusted and painted with a primer. There shall be a readily installed cable tray on the interior of both side panels for outgoing cable. All cables shall be rigidly secured using cable support bracket of non rotting material, before termination.

2.2.1.10 Where top entry is specified or required, there shall be a readily installed cable box for top entry cable.

2.2.1.11 Where the incoming feeder circuit breaker in the switchboard is 2500A and above, the switchboard shall be equipped with an arc protection system. The arc protection shall be installed against the internal arc in the switchboard in order to improve personnel safety to minimize damage to the switchgears in case of internal arc faults, thus improving the availability of the electricity service. The arc protection shall be integrated with protection relays or of stand alone type. The relays shall be in accordance to the requirements in Section 5.0. Only a simultaneous occurrence of over-current and arc incidence(s) shall activate the trip signal in the relay.

2.2.1.12 Arc sensors shall be mounted in the switchboard. The arc sensors for detecting the arc shall be of photo transistor or lens sensors. The arc sensors shall in practice be installed within the cable compartment of the outgoing feeder, main incoming circuit breaker and busbar compartment. The arc protection system shall include a self -supervision function covering all equipment, including the arc sensors. All internal faults shall be indicated on the arc protection unit and an alarm contact shall be activated. The arc-monitoring unit shall contain a display capable of indicating the exact compartment of the fault after the tripping.

2.2.1.13 All outgoing MCCBs in the switchboard where the incoming feeder circuit breaker is rated 400A and above shall be provided with panel mounting external operating handle with padlocking facilities.

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2.2.2 WALL MOUNTED SWITCHBOARDS

2.2.2.1 The switchboard shall be fabricated from sheet steel of thickness not less than 2.0mm. The enclosure shall be of all welded construction with sheets bent where possible so as to minimise the number of welded joints. The four sides of the enclosure shall be returned at the front to facilitate fixing of front cover plates. The front cover plates or doors shall be of box formation and flanged to facilitate fixing to the enclosure.

2.2.2.2 The front cover of the switchboard shall be provided with grummets and dust seal to exclude dust and dirt. Meshed louvre or ventilation vent with filter shall be provided at both sides for ventilation. All edges shall be rounded. Serrated star washers shall be fitted to ensure satisfactory earthing of the front cover. The switchboard shall undergo de-rusting treatment, anti-rust treatment and be finished with epoxy dry-powder and oven baked semi-gloss beige colour.

2.2.2.3 The switchboard shall not be mounted directly to the wall or structure. It shall be firmly bolted/welded on to galvanised C-channel brackets which in turn shall be bolted to the wall or structure by means of bolts and nuts. The top of the switchboard shall not be higher than 2100mm and the bottom shall not be lower than 900mm from the floor.

2.3 BUSBARS

2.3.1 Busbars shall conform to BS EN 13601 and shall be tinned hard drawn high conductivity copper with an adequate uniform rectangular cross section to carry continuously their rated current without overheating. They shall be rigidly mounted on non-hygroscopic insulators so as to withstand any mechanical stresses to which they may be subjected under maximum fault condition.

2.3.2 Busbar sizes must not be less than that specified in the Drawings. However if the busbar sizes are not specified, then the busbar rating shall be based on a current density of not more than 1.5 A/sq. mm. In any case, the main busbars rating shall not be less than the rating of the incoming switchgear (I_n). All busbars whether horizontal or vertical, shall be of the same size.

2.3.3 The main busbars shall be run for the full length of the switchboard without reduction in size. Neutral busbar shall be of full size and full length as the phase busbars. Connections shall be made up with bronze or other copper alloy and nuts utilising tension washers on both outer faces. Where multiple parallel bars are used, they shall be separated by tinned copper spacers at spacing equal to the busbar thickness.

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2.3.4 The main busbar shall be arranged in a horizontal plane in the order neutral-blue-yellow-red, viewed from the rear of the switchboard. Busbars shall be painted at appropriate points with colours red, yellow, blue and black to denote the phases.

2.3.5 Tinned copper earthing bar of cross sectional area not less than 50mm x 6mm shall run along the switchboard for its entire length. This switchboard earthing bar shall be fastened and bonded at the base to each vertical frame member of the switchboard. At least one earthing bar of similar cross sectional area shall run the full height of the switchboard and connected to the main earthing bar. All earthing bars shall be identified with green and yellow (twin-coloured) colour.

2.3.6 Distribution busbars shall be sized in accordance with the maximum outgoing switchgear rating. Connections from busbars to the switchgears shall be effected by means of copper conductors securely clamped to the busbars and colour coded to identify the phase and neutral conductors. Copper conductor either bare tinned busbars or insulated cable shall be rated in accordance with the current rating of the switchgear. Neutral conductor shall be of full size as phase conductor. Coloured cable sleeve shall be shrouded for cable end termination.

2.4 METER PANELS

2.4.1 The metalclad, mild steel or other approved material with thickness not less than 1.5mm meter panel of box formation shall be installed adjacent to, but physically separated from the main switchboard. Suitable flexible and/or rigid galvanised steel conduit with approved adaptors shall be supplied and fitted between the main switchboard and the meter panel. The design, construction and method of installation of the meter panel shall be to the requirement of Supply Authority or Licensee.

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2.5 OTHERS

2.5.1 All secondary wiring shall be of not less than 1.5 sq. mm. section insulated with PVC and shall be fixed securely without strain by cleats of the compression type. All screws, locknuts, washers, bolts etc. shall be of copper alloy type.

2.5.2 Indicating lights shall be long life coloured LED type. All indicating lights shall be adequately ventilated and easily be replaced from the front of the panel without the use of extractors.

2.5.3 Instruments, meters, relays, protective fuses etc. located on the front of the switchboard shall be so positioned that as far as possible, each instrument, meter, relay, protective fuse etc. is adjacent to the unit which it is associated. All relays shall be of heavy duty type, unaffected by external vibration and capable of operation in any position. All instruments, meters, relays, equipment etc. shall be fully tropicalised.

2.5.4 One number approved anti-condensation heater shall be installed for every two sections at the switchboards. Each heater shall be complete with automatic thermostat control, ON-OFF switch and indicating lamp.

2.5.5 Engraved labels with white lettering on a black background shall be fastened or riveted on the front panels of each switchgear and item of equipment. The wording shall be approved by the S.O.'s Representative. Engraved name plate showing the relevant earth fault setting, overcurrent setting, current transformer ratio, fuse rating, name of the circuit to which it is connected, etc. shall be fixed to switchgear panels to which it refers.

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3.0 DISTRIBUTION BOARDS & CONSUMER UNITS

3.1 All Distribution Boards (metalclad and all insulated) shall be installed at locations indicated in the Drawings or as directed by the S.O.'s Representative. The Distribution Boards shall be assembled by licensed switchboard manufacturer, registered with Suruhanjaya Tenaga (ST) and Jabatan Kerja Raya.

3.2 They shall comply with MS IEC 60439-3 and unless otherwise specified, shall be surface mounted metalclad type. The sheet steel shall have minimum thickness of 1.2mm. They shall have hinged cover, rust-proof and finished with oven baked epoxy powder coating. Knockouts or other approved form of cable entries and suitable brass earthing bolt and nut shall be provided.

3.3 The Distribution Boards shall be equipped with HRC fuses or Miniature Circuit Breakers (MCB) of rating as specified in the Drawings. HRC fuses shall comply with relevant parts of IEC 60269. MCB shall have rupturing capacity not less than that indicated on Drawings and/or Bill of Quantities and shall comply with MS IEC 60898.

3.4 The busbars shall be hard drawn high conductivity copper. The current rating of the busbars shall not be less than the incoming switchgear rating. The neutral and earth connection for each circuit shall be individually connected to the neutral and brass earth bar/terminal respectively. The sequence of termination of the neutral and earth wires shall correspond to that of phase circuit.

3.5 For all -insulated Distribution Board/Consumer Unit, the main switch shall be double pole MCB (Miniature Circuit Breaker) provided with a clear indication of 'ON-OFF' positions. The main switch shall comply with MS IEC 60947-3 and have fully shrouded incoming cable terminals. The contacts shall be of long switching life type.

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3.6 Where surge protective device is specified, the device and its associated equipment shall be housed in separate compartment immediately after where the incoming switchgear is connected.

3.7 All outgoing cables shall have alphanumeric circuits number labels. The labels of the neutral and earth shall correspond to that of the phase circuit.

3.8 Engraved labels with white lettering on a black background shall be fitted externally (using rivet) on the front cover of the Distribution Board/Consumer Unit describing its usage and with a suitable designation for identification.

3.9 Each Distribution Board shall be provided with a laminated schematic diagram and paste on the inside cover of the Distribution Board. The details shall include fuse rating/MCB rating, cable size, number and type of loads etc. The description of each circuit printed thereon shall include the corresponding circuit number in the as installed schematic diagram.

3.10 All Distribution Boards shall be provided with top and bottom entry/exit with minimum 50mm x 50mm pre-cut hole. The opening shall be fitted with flat, removable gland plate to cover the hole.

3.11 Where Distribution Board is specified to be installed at special service conditions as per clause 7 of IEC 61439-3:2012 and clause 7.2 of IEC 61439-1:2011 where variations in temperature and humidity take place at such speed where condensation is liable to occur inside it, each Distribution Board shall be provided with meshed louvre or ventilation vent with filter for adequate ventilation and/or one number anti condensation heater complete with automatic thermostat control, ON OFF switch and indicating lamp.

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4.0 SWITCHGEARS

4.0.1 All switchgears shall have voltage and frequency rating suitable for the power system to which they are connected. The current rating shall not be less than the specified in the Drawing and/or Bill Quantities. They shall conform to the latest MS, MS IEC or IEC standards.

4.1 AIR CIRCUIT BREAKERS

4.1.1 Air circuit breakers (ACB) shall be of withdrawable metalclad, flush mounted, horizontal drawout isolation and air break type suitable for installing on cubicle type of switchboard. They shall be three or four poles type as specified and shall comply fully with MS IEC 60947-1 and 60947-2. They shall be ASTA, KEMA or other accredited laboratories certified for minimum rupturing capacity, rated short time withstand current, (I_{cw}) of 50kA at 400V for 1 second or otherwise specified.

4.1.2 They shall consist of quick-make, quick-break, mechanically and electrically trip free mechanism arranged to give double break in all poles simultaneously. The closing mechanism shall be of stored energy type, either manually or electrically charged. Mechanical `ON' and `OFF' or 'I' and 'O' indicators shall be provided. The tripping mechanism shall be equipped with push button for independent manual tripping and shall be stable and not being opened by shocks.

4.1.3 Each pole of the circuit breaker shall be provided with an arc chute to extinguish the arc drawn between the breaker contacts each time a breaker interrupts current, and interpole barriers to reduce arcing time for rapid deionization of the arc and guard against flash over. The contacts shall be renewable type.

4.1.4 The operating mechanism and carriage shall have the following positions: -

4.1.4.1 Service- In this position the main and control contacts are engaged.

4.1.4.2 Test - In this position the main contacts are isolated but the control contacts are still engaged. It shall be possible to check the correct operation of the control circuits without energising the main circuit.

4.1.4.3 Isolated - Both main and control contacts are isolated.

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4.1.5 They shall be provided with marking to show the breaker positions with facility for padlocking the carriage in the Test and Isolated positions. They shall be equipped with the following interlock devices: -

4.1.5.1 Prevent withdrawal of breaker while the breaker is in closed position.

4.1.5.2 Prevent closure of breaker while the carriage is in any position between `fully isolated' and `fully home'.

4.1.6 The arrangement of the busbar connections shall be such that with the circuit breaker withdrawn, the live parts shall be protected, either by suitable shrouding or lockable shutters.

4.1.7 Minimum four numbers (2 -Normally-Open, 2-Normally-Close) double break type auxiliary contacts shall be provided.

4.1.8 Mechanical interlocks and/or electrical interlocks, where specified, shall be provided. Mechanical interlock shall be of code key type, arranged to mechanically operate the trip mechanism latch so that the breaker can only be closed when the key is trapped in the lock. Electrical interlock shall be controlled by means of operation of auxiliary switches of another breaker designed to cut out the closing coils and mechanism of the parent breaker.

4.1.9 Where used as bus-coupler, they shall be of 4 pole type and provided with electrical and/or mechanical interlocks as required so that it is not possible for the coupler to close with its associated main incoming supply breakers closed.

4.1.10 Where used as incoming feeder from supply source (either from transformer, generator set or coupler), they shall be of 4 pole type.

4.1.11 The neutral of the 4 pole type ACB terminals shall be of the same size as the phase.

4.1.12 The frame of ACB shall be bonded to the switchboard earthing bar using of 3mm x 25mm tinned copper tape.

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4.2 MOULDED CASE CIRCUIT BREAKERS

4.2.1 Moulded case circuit breakers (MCCB) shall have the number of poles as specified in the Drawings and/or Bill of Quantities. They shall comply with MS IEC 60947-1 and MS IEC 60947-2. They shall be fully tropicalised and suitable to be used up to an ambient temperature of 40°C, enclosed in glass-reinforced polyester moulded case and suitable for use on 230/400V, 50Hz. a.c. supply system.

4.2.2 They shall be of the quick-make, quick-break type having manually operable toggle type handle. Permanent position indicators shall be provided to show status of the breaker. When tripping occurs, the handle shall be in the `trip' position midway between the 'ON' and 'OFF' or 'I' and 'O' position so as to provide positive indication of automatic interruption. The operating mechanism shall be non-tamperable. The MCCB shall have trip-free feature to prevent the breaker from being closed against fault conditions. Multipole MCCB shall have common-trip operating mechanism for simultaneous operation of all poles.

4.2.3 The tripping units shall be one of the following types: -

4.2.3.1 Thermal-magnetic type with bimetallic elements for inverse time-delay overload protection and magnetic elements for short circuit protection.

4.2.3.2 Solid state trip unit with adjustable overload protection and adjustable short circuit protection with or without adjustable time-delay.

4.2.4 An arc extinguisher shall be incorporated to confine, divide and extinguish the arc drawn between the breaker contacts each time a breaker interrupts current. The contacts shall be of non-welding type.

4.2.5 Unless otherwise specified in the Drawings and/or Bill of Quantities, the minimum rated ultimate short circuit breaking capacity (I_{cu}) of the MCCB shall be 50kA rms at 400V for switchboards connected to transformer or Supply Authority's or Licensee's incomer and 25kA for the subsequent switchboards.

4.2.6 The rated service short-circuit breaking capacity (I_{cs}) shall be 100% of the rated ultimate short-circuit breaking capacity (I_{cu}) at 400 volts for incoming feeder, and for all outgoing feeder I_{cs} shall be 50% of I_{cu}.

4.2.7 Unless otherwise specified the rated ultimate short circuit breaking capacity (I_{cu}) for MCCB at Distribution Board shall be not less than 10kA at 230/400V and I_{cs} shall not be less than 50% I_{cu} at 230/400V.

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4.2.8 If current limiting types of MCCB are used, they shall be equipped with current limiting device of either permanent self-resetting power fuse type or magnetic repulsion moving contact type.

4.2.9 The current limiting device shall coordinate with the normal trip mechanism so that all fault and overload currents occurring within the safe capability of the MCCB shall cause the MCCB to open, and all currents occurring beyond the capability of the MCCB shall cause the current limiting devices to operate.

4.2.10 If required, the MCCB shall have facilities for shunt trip, under-voltage/no-volt trip, externally connected earth fault protection, externally connected overcurrent protection etc.. They shall also have auxiliary contacts, accessories etc. for indication, alarm and interlocking purposes if necessary. In area where is specified, and door interlocking facilities to prevent the panel door from being opened to access to the MCCB in closed position, shall be provided.

4.2.11 Where used as incoming feeder from supply source (either from transformer and/or generator set), they shall be of 4 pole type.

4.3 MINIATURE CIRCUIT BREAKERS

4.3.1 Miniature Circuit Breakers (MCB) shall be of the type approved by Suruhanjaya Tenaga and JKR.

4.3.2 Unless otherwise indicated in the Drawings and/or Bill of Quantities, (MCB) shall have breaking capacity not less than 6kA (rms) and of C-type with Class 3 energy limiting characteristics. They shall comply with MS IEC 60898-1 and/or MS IEC 60898-2, fully tropicalised and suitable for use on a 230/400V, 50Hz. a.c. system and up to an ambient temperature of 40°C.

4.3.3 They shall be quick-make, quick-break and trip free type complete with de-ion arc interrupters. The tripping elements shall be of thermal magnetic type with inverse time delay overcurrent and instantaneous short circuit characteristic. The response to overload shall be independent of variations in ambient temperature.

4.3.4 They shall be manually operated by means of toggle type handles having visual indication of whether the breaker is opened, closed or tripped. Multipole MCB shall be of all pole protected type and provided with common-trip mechanism for simultaneous operation of all the poles.

4.3.5 Where used as incomer, they shall be of 2 pole type.

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4.4 RESIDUAL CURRENT DEVICE

4.4.1 Residual Current Device (RCD) shall be of the type approved by Suruhanjaya Tenaga and JKR.

4.4.2 RCD shall be residual current operated circuit breakers without integral overcurrent protection (RCCB) and residual current operated circuit breakers with integral overcurrent protection (RCBO) shall be current operated functionally independent of line voltage type, suitable for use on a 230/400V, 50Hz. a.c. system and up to an ambient temperature of 40°C. RCCB shall comply with MS IEC 61008 -1 and MS IEC 61008-2-1 and RCBO shall comply with MS IEC 61009-1 and MS IEC 61009-2-1. They shall be of either two-pole or four-pole type as indicated in the Drawings and/or Bill of Quantities. The rated current and the rated residual operating current of the RCCB or RCBO shall be as specified in the Drawings and/or Bill of Quantities. Rated conditional short circuit current (I_{nc}) shall be of minimum 6kA. For RCBO, protection against overcurrent shall of C-type with Class 3 energy limiting characteristic complying with MS IEC 60898-1 and MS IEC 60898-2. The breaking capacity shall not be less than 6kA.

4.4.3 RCCB and RCBO shall provide resistance against nuisance tripping due to an impulse voltage or transient overvoltage.

4.4.4 RCCB and RCBO shall be A or AC type unless otherwise specified.

4.4.5 Test push button and visual indication for 'ON' and 'OFF' or 'I' and 'O' shall be provided. They shall be equipped with screw clamping type of cable terminals, which shall be covered by moulded phonolic plastic with knockouts for cable entry.

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4.5 FUSE SWITCHGEARS

4.5.1 Fuse-switch disconnector and switch-disconnector fuse shall be of totally enclosed, flush or surface mounting, double air break, quick-make and quick-break type complete with phase barriers and fully comply with MS IEC 60947-1 and MS IEC 60947-3. They shall be of utilization category AC-23A. They shall be equipped with operating handle, position ON-OFF indicator and mechanical door interlock to prevent the cover from being opened with the switch closed and the switch being closed with the cover opened. However this interlock shall be able to be defeated by competent person for maintenance purpose. Terminals and fuses shall be minimum IP20. The doors shall be provided with dust seal.

4.5.2 They shall be equipped with replaceable HRC fuses. The fuse holder shall have shrouded base contact with provision for busbar mounting and front wiring. The fuse links and fuse carrier shall comply with relevant parts of MS IEC 60269. Suitable knockouts shall be provided for cable entry.

4.6 ISOLATING SWITCHES

4.6.1 Isolating switches or switch-disconnector shall be of metalclad or high impact insulating material (e.g. polycarbonate) type. They shall fully comply to MS IEC 60947-1 and MS IEC 60947-3. The degree of protection shall be IP54 for indoor installation and IP65 for outdoor installation. They shall be able to operate continuously at full current rating without de-rating, capable of making and breaking currents under normal condition and when in open position, providing isolation from source of electrical energy for reasons of safety.

4.6.2 They shall be quick-make, quick-break type suitable for use on 230/400V, 50Hz. a.c. system and shall have padlocking facilities to secure against unauthorised operation. They shall be provided with removable top and bottom end plates or knockouts for cable entry. The enclosure, the isolating mechanism and all other accessories shall be from the same manufacturer.

4.6.3 The enclosure for metalclad type shall comprise of heavy gauge steel plates rust protected and finished grey stove enamel. Front access doors for metalclad type, which is detachable, shall be fitted with dust-excluding gasket and shall be interlocked to prevent opening when the switch is 'ON'. However this interlock shall be able to be defeated by competent person for maintenance purpose. It shall be provided with, if required, facilities for lock-on and lock-off the operating handle.

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4.7 CONTACTORS

4.7.1 Contactor shall have the number of poles as specified in the Drawings and/or Bill of Quantities. They shall comply with IEC 60947-1 and 60947-4-1. They shall be fully tropicalised, suitable to be used up to an ambient temperature of 40 °C and suitable for use on 230/400 V, 50 Hz. a.c. supply system.

4.7.2 The contacts shall be of quick-make and quick-break type, dust-proof and rust protected. They shall be of utilization category as per Table 4A.

Current	Utilization Category	Typical Applications
AC	AC-1	Non Inductive or slightly inductive loads, resistance furnaces, heater
	AC-2	Slip-ring motors: switching off
	AC-3	Squirrel-cage motors: starting, switching off motors during running *Most typical industrial application*
	AC-4	Squirrel-cage motors: starting, *plugging[1], *inching[2]
	AC-5a	Switching of electric discharge lamps
	AC-5b	Switching of incandescent lamps
	AC-6a	Switching of transformers
	AC-6b	Switching of capacitor banks
	AC-7a	Slightly inductive loads in household appliances: mixers, blenders
	AC-7b	Motor-loads for household applications: fans, central vacuum
	AC-8a	Hermetic refrigerant compressor motor control with manual resetting overloads
	AC-8b	Hermetic refrigerant compressor motor control with automatic resetting overloads

*(1) Plugging - Stopping a motor rapidly by reversing the primary power connections.
*(2) Inching - Energizing a motor repeatedly for short periods to obtain small incremental movements.

Table 4A - Utilization Categories

4.7.3 The contactor shall have multiple auxiliary contacts, and unless otherwise specified shall be normally-open.

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4.8 AUTOMATIC TRANSFER SWITCHING EQUIPMENT

4.8.1 The automatic transfer switching equipment (ATSE) shall comprise of a transfer switching device and a necessary monitoring and transfer control device for monitoring supply circuits and for transferring load circuits from the normal supply to an alternative supply in the event of a monitored supply deviation and automatically returning the load to the normal supply when it is restored.

4.8.2 ATSE shall be of utilization category AC 33B and shall comply to MS IEC 60947-1 and IEC 60947-6-1.

4.8.3 Unless otherwise specified, the operating mechanism of the ATSE shall be reliably, electrically and mechanically interlocked to prevent simultaneous connection to both normal mains and alternative supplies.

4.8.4 Unless specified otherwise in the Bill of Quantities and/or Drawings, the transfer switching device of an ATSE shall be of automatic changeover contactors Class CC type in accordance with IEC 60947-1 and IEC 60947-4.The automatic changeover contactors shall be bar mounted type with fixed bar and moving shaft made of steel and bearing supports made of aluminium/bronze alloy. They shall be of double air-break, quick-make and quick-break type complying with MS IEC 60947-1 and IEC 60947-4-1. They shall be dust-proof, rust protected, fully tropicalised and suitable for use on 230 V/400 V, 50 Hz A.C. system.

4.8.5 The operating coil shall be 230 V/400 V 50 Hz A.C. type and shall operate satisfactorily when the voltage at the coil terminals is between 85% and 110% of the nominal voltage. The electromagnet shall be of laminated type.

4.8.6 The automatic changeover contactors shall be four pole type. Each pole shall comprise three main parts: -

4.8.6.1 The main contacts shall be of 'butt-contact' pattern without sliding or rolling and shall operate with absolute minimum contact bounce.

4.8.6.2 The blow out coil shall be rated to carry the total current flowing through the main pole and according to the thermal rating of the contactor.

4.8.6.3 The arc chute shall be De-ion type or the type having 'arc ‘splitter' for rapid extinction of electric arc. Each arc chute shall have a steatite disc on its internal faces for preventing rapid erosion of the chute by the effect of arcs. The arc chutes shall be easily removable to allow inspection of the main contacts and where necessary their replacement.

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4.8.7 The main contacts shall able to carry continuously the rated current, capable of making and withstanding short-circuit currents without damage in an enclosure having an ambient temperature up to 40 ^{0}C.

4.8.8 Unless otherwise specified, a minimum of four normally close and four normally open auxiliary contacts shall be provided.

4.8.9 A transparent protection screen of full compartment size shall be provided in front of the automatic changeover contactors.

4.8.10 For Class CB where the circuit breakers are specified as transfer switching devices, the circuit breakers shall comply with MS IEC 60947-1 and MS IEC 60947-2. Unless specified otherwise, the rated short-time withstand current shall be of the same rating for the circuit breaker receiving supply from the Licensee or Supply Authority.

4.8.11 For class PC, the ATSE shall comply with MS IEC 60947-1 and MS IEC 60947-6-1.The ATSE shall be of open transition (break -before-make) type or closed transition (make-before -break) type according to the application stated on the design. Unless there is no type specified, all ATSE shall be of open transition type.

4.8.12 ATSE shall have the overlapping neutral feature during synchronizing and changing over from normal mains supply to an alternative supply and vice versa.

4.8.13 ATSE shall be complete with a monitoring and transfer control device for monitoring supply circuits and for transferring load circuits from the normal mains supply to an alternative supply in the event of a monitored supply deviation and automatically returning the load to the normal mains supply when it is restored.

4.8.14 The monitoring and transfer control device shall be of microprocessor based controller comprising automatic transfer switching module or combination of automatic transfer switching module and automatic mains failure module.

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5.0 PROTECTION RELAYS

5.1 The protection device shall provide either instantaneous or inverse time lag characteristics in the overload range and instantaneous with or without time delay in the short circuit range as specified in the Drawings and/or Bill of Quantities. The protection device shall be of the type acceptable to the Supply Authority or Licensee and JKR. The protection relays shall be of panel flush mounting type. All relays shall comply with relevant parts of IEC 60255.

5.2 Overcurrent and earth fault protection shall be provided by externally connected current transformers.

5.3 Unless specified in the drawing and/or Bill Of Quantities, electromechanical overcurrent and earth fault relay shall be of Inverse Definite Minimum Time (IDMT) type.

5.3.1 For overcurrent relay of IDMT induction disc type, current settings shall be from 50% to 200% of rated current adjustable in seven equal steps and time multiplier settings from 0.1 to 1.0 adjustable continuously.

5.3.2 Earth fault relay of IDMT induction disc type shall have current settings from 10% to 40% of rated current adjustable in seven equal steps and time multiplier settings from 0.1 to 1.0 adjustable continuously.

5.4 Earth leakage relay (ELR) shall be of the type suitable for use on a 230/400V, 50Hz system and up to ambient temperature of 40 ^{o}C. ELR shall be provided with test button for simulation of a fault, earth leakage, LED indicator, a reset button, protection against nuisance tripping due to transient voltage and d.c. sensitive. Unless otherwise specified in the Drawings and/or Bill of Quantities, ELR shall be of adjustable current sensitivity and adjustable time delay type.

5.5 The selectivity range for current sensitivity shall be 0.03A to 10A and the time delay selectivity range of 0 second to 1 second. ELR shall be incorporated with matching balanced core current transformer and shunt trip coil for the circuit breaker to which it controls the tripping shall also be provided.

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5.6 Unless specified in the Drawings and/or Bill of Quantities, the microprocessor based protection relays shall be rated at 230V/400V and operating voltage shall be in a range from 90V to 250V. The relays shall be housed in robust panel flush mounting case and shall be fully tropicalised and suitable to be used up to an ambient temperature of 50 ^{o}C and relative humidity of 95%.

5.6.1 Unless otherwise specified, the microprocessor based protection relays shall be of combined three phase over current and earth-fault protection with instantaneous, definite time and inverse time characteristics. Time / current characteristic of IDMT overcurrent and earth fault relays shall be of standard inverse curve (3/10).

5.6.2 The microprocessor based protection relays shall give numerical digital readout of set values, actual measured values and recorded values. The relays shall include a serial communication port for external connection to facilitate external reading, setting and recording of relay data and parameters by a personal computer (PC). PC connecting cable and parameter reading/setting /recording PC program shall be provided.

5.6.3 The microprocessor based protection relays shall be incorporated with built-in self-supervision system with auto-diagnosis. The self-supervision system shall continuously monitor the relay microprocessor programs. If a permanent fault is detected, an alarm indication shall be given. A 230V/5A alarm contact for connection to external alarm shall be provided.

5.6.4 If current and voltage measurements are specified, the microprocessor based protection relays shall make available these measurements for local display. The measurements shall include phase currents, phase-to-phase voltages and phase-to neutral voltages.

5.6.5 The microprocessor based protection relays shall comply with relevant parts of IEC 60255 and shall also comply with relevant parts of IEC 61000 on electromagnetic compatibility.

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6.0 MEASURING INSTRUMENT AND ACCESSORIES

6.0.1 Measuring instrument and accessories shall comply with the relevant IEC Standards. They shall meet the requirement as specified in the Drawings and/or Bill of Quantities.

6.1 MEASURING INSTRUMENT

6.1.1 Measuring instrument shall be of panel flush mounting type with square escutcheon plate finished matt black and pressed steel case. They shall be of industrial grade type adequately shielded against stray magnetic fields, conform to the measuring scales and arrangements as shown in the Drawings and calibrated for correct readings. They shall comply with MS 925 and relevant parts of IEC 60051. External zero adjustment shall be provided for ammeters and voltmeters.

6.1.2 Ammeters, unless otherwise specified, shall be of moving iron type having continuous overload capacity of 120% of rated value and full scale value accuracy of ±2%. They shall be provided with maximum demand indicator, if specified.

6.1.3 Voltmeters shall be of moving iron type having overload capacity of 200% of rated value and full scale value accuracy of ±1.5%.

6.1.4 Kilowatt-hour meter shall be of 6 numbers wheel cyclometer aluminium type with both the current and voltage coils on laminated cover fabricated from high quality silicon steel strip. They shall have overload capacity of 200% of rated value and accuracy of ±0.5% at the supply voltage and frequency characteristic.

6.1.5 Power factor meters shall be of balanced type using ferrodynamic, cross-coiled mechanism with measuring range from 0.5 lagging to 0.5 leading. Full scale value accuracy shall be ±1.5%.

6.1.6 Frequency meters shall be of reed type with frequency range from 45Hz. to 55Hz. and accuracy of ±5%. If specified in the Drawings and/or Bill of Quantities, the microprocessor based power meter shall be rated at 230V/400V and operating voltage shall be in a range from 90V to 265V.

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6.1.7 The meters shall be housed in robust panel flush mounting case and shall be fully tropicalised and suitable to be used up to an ambient temperature of 50°C and relative humidity of 95%. The meters shall give direct numerical digital readout of actual measured values and recorded values. The meters shall include one serial communication port for external connection to facilitate external reading and recording of meter data and parameters.

6.1.8 The measurements and their accuracy of the microprocessor-based meters shall be as per Table 6A: -

Parameters / measurements	Accuracy
Volts (V): line-line / line-neutral	0.5% of reading ± 2 digit
Currents (A): per phase	0.5% of reading ± 2 digit
Frequency (Hz)	0.1 Hz ± 1 digit
Power Factor: total	1% of reading ± 2 digit
Active Power (kW): total	1% of reading ± 2 digit
Reactive Power (kVAr): total	1% of reading ± 2 digit
Apparent Power (kVA): total	1% of reading ± 2 digit
Active Energy (kWh): total	1% of reading
Reactive Energy (kVArh): total	1% of reading
Maximum Demands (A, W, VA): total	1% of reading ± 2 digit

Table 6A: Accuracy of Microprocessor-based Meter

6.1.9 If harmonics content measurement is specified, individual and total harmonics distortion on the current and voltage up to 30th harmonic shall be measured with the accuracy of 1% of reading.

6.1.10 There shall be a custom display screen, which can be programmed to display customised specific parameter requirements.

6.1.11 All data shall be continuously and concurrently logged, recorded and stored in internal non-volatile memory. All time base logged-in data can be retrieved and downloaded to a personal computer (PC) using serial communication port. PC connecting cable and data retrieving PC program shall be provided.

6.1.12 The meters shall comply with IEC 60359 and IEC 60688. The meters shall also comply with relevant parts of MS IEC 61000 on electromagnetic compatibility.

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6.2 CURRENT TRANSFORMERS

6.2.1 Current transformers shall comply fully with MS 1202 and IEC 60044-1 and shall have short time rating not less than that of the switchboard in which they are incorporated. The secondary shall be rated for 5A. They shall be adequately rated in VA to carry the summation of all VA burdens of the connected loads but in any case, the rating shall not be less than 15VA. They shall be capable of withstanding, without damage, on open circuit secondary with full primary current.

6.2.2 They shall be constructed from high quality silicon steel core. They shall be installed inside the switchboard in such a way that it is easily accessible for maintenance purpose. Identification labels shall be fitted giving type, ratio, rating, output and serial numbers.

6.2.3 Unless otherwise specified, current transformers used for measuring and metering shall be of Class 1.0 accuracy and those used for protection shall be of Class 10P10 accuracy.

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7.0 SURGE PROTECTIVE DEVICE

7.1 The surge protective devices (SPDs) shall be one-port type compatible with the 230/400V, 3 phase, 4 wire, 50Hz with solidly earthed neutral supply system it is protecting. The SPDs shall be of the type complying with MS IEC 61643-1, MS IEC 61643-12 and IEEE Std C62.41.2 and in accordance with recommendations of MS IEC 62305 and the relevant parts and sections of MS IEC 60364.

7.2 If the specifications conflict in any way, with any or all of the above/ standards, the specification shall have precedence and shall govern.

7.3 The SPDs shall be designed for the average isoceraunic level of approximately 200 thunder-days per year.

7.4 The SPDs modes of protection shall be each phase-to-neutral (L-N), each phase-to-earth (L-E) and neutral-to-earth (N-E) for either single phase or three phase supply system.

7.5 The SPDs shall be of voltage limiting type with metal oxide varistors (MOVs), or voltage switching type with gas discharge tube (GDT)/spark gap, or combination type with MOVs and GDT/spark gap. MOVs and GDT shall comply with MS IEC 61643-331 and MS IEC 61643-311 respectively.

7.6 The maximum continuous operating voltage (Uc) of SPDs shall be minimum 275V for SPDs connected between L-N and L- E. When SPDs connected between N-E, the rating of Uc shall be minimum 230V. The continuous operating current (Ic) for each mode of protection shall not exceed 3mA. In the case where the MOVs are used, the SPDs shall be provided with integrated thermal protection to avoid thermal runaway due to degradation.

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7.7 The SPDs to be installed with respect to the location of category shall be as in Table 7A. The maximum discharge current (Imax) of SPDs shall be declared by the SPD manufacturer by submitting the V-I characteristic of a MOVs / GDT / spark gap.

7.8 The SPDs shall be equipped with visual indicator showing the protection status of the SPDs. Unless otherwise specified, SPDs shall be provided with auxiliary contact for connection to remote monitoring of SPDs protection status. A durable label with red lettering on a white background with words as stated below shall be fastened externally on the front cover of the SPDs compartment.

AMARAN

1. Pemasangan ini dilindungi oleh Surge Protective Device (SPD).
2. SPD tidak lagi berfungsi apabila “petunjuk” bertukar warna / tidak menyala
3. Sila buat pemeriksaan pada SPD secara bulanan
4. Sila hubungi ‘orang kompeten’ untuk penggantian SPD.
5. Pastikan juga ‘circuit breaker’ ke SPD sentiasa berada dalam keadaan ON (I).

7.9 The size of connecting conductors shall be as recommended by the SPD manufacturer. The connecting conductors shall be as short as possible (preferably not exceeding 0.5m for the total length) and shall be tightly bound together throughout the whole length with cable-ties or other approved means. Either a MCCB or a fuse of rating as recommended by the SPD manufacturer shall be provided for disconnecting the SPDs from the system in the event of SPDs failure or for maintenance. In the case where an MCCB is used, the breaking capacity of the MCCB shall comply with the rated ultimate short circuit breaking capacity (I_{cu}) for the switchboards and DB respectively. The Ics shall be 50% of the I_{cu}.

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Location Category	1.2/50 µs (U_{oc}) Voltage Generator	8/20 µs (I_{sc}) Current Generator	Voltage Protection Level (U_p)	Maximum Discharge Current, I_{max} (8/20 µs) per mode
Main Switchboard (MSB)	≥ 20 kV	≥ 10 kA	≤ 1800 V	≥ 65 kA
Sub-Switchboard (SSB) receiving energy from MSB located in the same building	≥ 10 kV	≥ 5 kA	≤ 1500 V	≥ 40 kA
SSB receiving energy from MSB located in other building	≥ 20 kV	≥ 10 kA	≤ 1800 V	≥ 65 kA
Distribution Board (DB) receiving energy from SSB located in the same building *(for cases where the SSB located in the same building with MSB)*	≥ 6 kV	≥ 3 kA	≤ 1200 V	≥ 20 kA
Distribution Board (DB) receiving energy from SSB located in the same building *(for cases where the SSB located in other building with MSB)*	≥ 10 kV	≥ 5 kA	≤ 1500 V	≥ 40 kA
DB receiving energy from the licensee or MSB/SSB located in other building	≥ 20 kV	≥ 10 kA	≤ 1500 V	≥ 40 kA
Socket Outlet or Terminal Equipment	≥ 2 kV	≥ 1 kA	≤ 500 V	≥ 10 kA

Table 7A – SPDs Location Categories

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8.0 BUSBARS TRUNKINGS

8.1 Busbar Trunkings System (busduct) shall comply with MS IEC 60439-2, pre-assembled, totally enclosed type and shall be as specified in the Drawings and/or Bill of Quantities.

8.2 The insulation of the busbars in busduct shall be one of the following types as:-

8.2.1 Air Insulated
8.2.2 Resin Encapsulated Insulated
8.2.3 Epoxy Insulated
8.2.4 Polyester Film minimum Class B Insulation

8.3 Busbar trunkings shall be suitable for operation on a 400 V, 3 phase, 4 wire, 50Hz. system with solidly earthed neutral. The rated short-time withstand current, Icw shall be tested for 1 second as specified in MS IEC 60439-1.

8.4 The neutral busbar shall be of the full size as the phase busbars.

8.5 The housing shall be of galvanised sheet steel of not less than 1.5mm thickness finished with epoxy dry-powder and oven baked enamel grey. Fire-resisting barriers shall be included as an integral part of each bus duct length and fitting. The maximum length of the busduct shall be not more than 3000mm and the tap-off openings for plug-in units shall be provided at every interval of not more than 900mm. Unless otherwise specified, the degree of protection shall be IP42 for indoor installation and IP65 for outdoor installation in accordance to MS IEC 60529.

8.6 Busbars shall be of hard drawn tinned high conductivity copper to BS EN 13601. The busbar current rating shall not be less than that specified in the drawing based on current density as per table 8A below. The busbars shall be fully insulated over its entire length except joint parts and totally enclosed in the housing. The insulation shall be seamless and also be flame-retardant. Earth continuity of the busduct shall be provided by continuous length of copper strip of dimension not less than 25mm x 3mm fitted on both external sides of the busduct.

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Current Rating (I)	Maximum Allowable Current density (A/mm²)
I ≤ 600A	2.67
600A < I ≤ 1800A	2.42
1800A < I ≤ 2000A	2.33
I >2000A	2.0

Table 8A : Current rating and current density for busbar trunking

8.7 The plug-in unit shall be mechanically interlocked with the busway housing to prevent installation or removal of plug-in unit while the switch in ON position. Plug-in unit enclosures shall make positive earth connections to the busduct housing before contacts are made with the busbars.

8.8 Expansion joints shall be provided for every interval of 3000mm at maximum, and at the end of busduct end box unit shall be provided. Busduct joints shall have sufficient contact length of adjacent sections so as to provide rigidity and strength. A spring material shall be used in jointing so as to ensure a constant contact pressure. All joint units, tee and elbow units, offset and combination elbow units, flanged end-feed units, expansion joint units and end joint units for the busduct system installation shall be the type manufactured and supplied by the same busduct manufacturer.

8.9 The busduct system shall be supported rigidly and adequately by external spring hangers mounted on channel base. The busduct system shall be supported at maximum intervals of 3000mm for vertical runs and 1500mm for horizontal runs so that the busduct will not be in contact with the wall or floor slab surfaces. The spring hangers shall be supplied by the busduct manufacturer.

8.10 The floor openings and wall openings where busduct passes through shall be sealed with fire-resisting barrier approved by Jabatan Bomba Dan Penyelamat Malaysia, according to the appropriate degree of fire resistance.

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9.0 SYSTEM OF WIRING

9.0.1 The system of wiring shall be either surface wiring, concealed wiring, surface conduit wiring or concealed conduit wiring as indicated in the Drawings and/or Bill of Quantities. The wiring systems shall comply with MS IEC 60364-5-52. All wiring shall be run neatly and in an orderly manner. They shall be routed parallel to building wall and column lines in a coordinated manner with other services. The wiring throughout shall be on the 'looping-in system' and no 'tee' or other types of joints are allowed. No reduction of the strands forming the conductors are allowed at all terminals. Multi strand conductors with a minimum of 7 strands shall be used. All strands shall be effectively secured by approved means.

9.0.2 Wiring which are not embedded in concrete or concealed behind plaster shall be run in an accessible manner on the beams, underside of slabs or below pipes, ducts, and downdrops shall be run on the surface of columns or walls. Concealed wiring shall be installed in such a way that plaster can be applied over their thickness without being subjected to spalling or cracking. Cables serving different operating voltages and functions shall be segregated.

9.0.3 All cables shall be legibly marked on the external surface with at least the following elements; Manufacturer's identification, Voltage designation, Nominal area of conductor and Standard Numbers. Standard colour coded cable shall be used for three phase circuit to identify the phase conductors, neutral conductor and protective conductor respectively. Opening on floor, wall or partition through which cable, trunking, conduit or other wiring passes through shall be sealed according to the appropriate degree of fire resistance after the installation. Chipping and cutting of concrete are not allowed unless otherwise approved by the S.O.'s Representative.

9.0.4 The Electrical Contractor is required to work in conjunction with the building contractor for the provision of openings, trenches, core-holes, chases etc. as the building concreting work progresses. In steel frame structures, the wiring system shall be rigidly and securely supported and fastened in place onto the structural steel beams, purlins and columns by fasteners such as clamps, clips, anchors, straps, hangers, supports or similar fittings. The fasteners shall be designed and installed as not to damage either to steel structures or wiring system.

9.0.5 The fasteners shall be installed at intervals not exceeding 1000mm, and within 300mm of every outlet box, junction box, device box, cabinet or fitting. Fasteners shall be of spring steel and/or galvanised steel, and where wires, rods or threaded rods are used with fasteners, they shall be of rolled carbon steel. The fasteners shall be finished with zinc coatings to resist rusting. Samples for the fasteners used shall be submitted to S.O.'s Representative for approval before they are used. Unless otherwise approved by S.O.'s Representative, no welding on and/or drilling holes into any members or components of the steel frame structures for the installation of fasteners are allowed.

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9.1 TYPES OF CABLES

9.1.1 PVC INSULATED PVC SHEATHED CABLE

9.1.1.1 PVC insulated PVC sheathed cables shall be of 300/500V grade to MS 2112-3 and MS 2112-4 and 600/1000 V grade to MS 274. The conductors shall be of stranded plain annealed copper to MS 69 and MS
280. The insulation shall be suitable for continuous operation at a maximum cable temperature of 70°C and comply with MS 138.

9.1.2 PVC INSULATED CABLE

9.1.2.1 PVC insulated cable shall be of 450/750V grade to MS 2112-3 and MS 2112-4 and 600/1000V grade to MS 274. The conductors shall be of stranded plain annealed copper to MS 69 and MS 280. The insulation shall be suitable for continuous operation at a maximum cable temperature of 70°C and comply with MS 138.

9.1.3 XLPE/PVC CABLE

9.1.3.1 Cable shall be manufactured and tested in accordance to BS 5467 or IEC 60502 and shall have high conductivity plain copper stranded conductors, insulated with cross-linked polyethylene (XLPE), suitable for a voltage of 600/1000V laid together and bedded with extruded PVC and sheathed with PVC.

9.1.4 ARMOURED CABLE

9.1.4.1 **PVC/SWA/PVC CABLE** - Cable shall be manufactured and tested in accordance with MS 274 or BS 6346 and shall have high conductivity plain copper stranded conductors insulated with PVC suitable for a voltage of 600/1000V laid together and bedded with PVC, armoured with galvanised steel wires and sheathed with PVC.

9.1.4.2 **XLPE/SWA/PVC CABLE** - Cable shall be manufactured and tested in accordance to BS 5467 or IEC 60502 and shall have high conductivity plain copper stranded conductors, insulated with cross-linked polyethylene (XLPE), suitable for a voltage of 600/1000V laid together and bedded with extruded PVC, armoured with galvanised steel wires and sheathed with PVC.

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9.1.4.3 **XLPE/AWA/PVC CABLE** - Cable shall be manufactured and tested in accordance to BS 5467 or IEC 60502 and shall have high conductivity plain copper stranded conductors, insulated with cross-linked polyethylene (XLPE), suitable for a voltage of 600/1000V laid together and bedded with extruded PVC, armoured with aluminium wires and sheathed with PVC.

9.1.5 **MINERAL-INSULATED CABLES**

9.1.5.1 Mineral-insulated cables shall be manufactured complying with IEC 60702, IEC 60331 and BS 6387 Category C, W and Z for electrical circuit integrity in case of fire. The cables shall have been tested to comply with IEC 60332-1 and 60332-3 for flame retardance, and IEC 61034 for smoke obscuration. The cables shall be halogen free with low organic content and do not release any corrosive emission when subject to fire conforming to IEC 60754-2. The cables shall be able to withstand a short circuit temperature of 280°C for 5 seconds. For general lighting and power points final circuits, unless otherwise specified, cables of 600V insulation grade may be used.

9.1.5.2 For main circuits and major power points, the cables used shall be of 1000 volt insulation grade. They shall be installed strictly in accordance with the manufacturer's recommendation and instruction. The mineral-insulated cables shall be as specified:

9.1.5.2.1 Mineral-insulated copper clad sheathed copper conductor (MICC) cables comprise of pressure packed magnesium oxide insulation contained within a solid drawn ductile seamless copper sheath with solid high conductivity copper conductors; or

9.1.5.2.2 Mineral-insulated mineral sheathed copper conductor (MIMS) cables comprise of multi stranded high conductivity copper conductors wrapped with layers of glass mica composite tape flame barrier and be insulated with a non-melt cross linked mineral insulation and mineral sheathed.

9.1.5.3 Cables installed on walls shall be fixed by means of copper clips or copper saddles at appropriate spacing. The clips or saddles shall be secured by means of brass screws. Where cables are installed on cable trays, they shall be clipped at appropriate spacing by means of copper saddles. The saddles shall be secured by means of brass bolts and nuts. Where single core cables are used on multi-phase distribution work, the cables shall be laid on their phase groups whether flat or trefoil.

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9.1.5.4 Where single core cables pass through ferrous or other magnetic materials, the area surrounding the cables shall be replaced with non ferrous plate of appropriate dimensions. Adequate bonding shall be provided where cables break formation to enter terminating positions. Minimum bending radius shall be not less than 6 times the cable diameter and saddle spacing not more than 60 times the cable diameter or 500mm whichever is less.

9.1.5.5 Connection to motors, generators, transformers and other similar equipment shall be by one of the two methods listed below: -

9.1.5.5.1 The cable shall be clipped at the appropriate spacing up to a point adjacent to the equipment and an unsupported antivibration loop shall be left in the cable.

9.1.5.5.2 The cable shall be glanded into a suitable terminal box adjacent to the equipment and connection to the equipment being effected by means of mechanically protected flexible cable of adequate cross sectional area.

9.1.5.6 For mineral -insulated copper clad sheathed copper conductor (MICC) cables, termination shall be of cold seal type. Silicon rubber sleeve insulation shall be used to replace copper sheath stripped off near the termination for temperature not exceeding 150°C. For temperature exceeding 150°C, varnished glass sleeve insulation shall be used. Insulation and continuity tests shall be carried out before and after the cable is terminated. The insulation test reading shall be `infinity'. A blow lamp may be used for drying out cable ends.

9.1.5.7 If it is impracticable to cut to waste, in which event the cable should be brought to cherry red heat at about 600mm from the end and moisture driven carefully towards the cut end. It is absolutely essential that great care shall be taken to maintain earth continuity when terminating the cables. Dirt and metallic particles in the compound and any loose traces of dielectric left at face of the sheath after stripping shall be removed prior to sealing. Cold sealing compound shall be forced down one side of the pot only until slightly overfilling in order to avoid trapping of air at the base of the pot and to ensure that when the sealing disc is entered before crimping a completely solid insulation barrier is effected.

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9.1.5.8 All other necessary accessories such as tap-off units, joint boxes, brass compress ring glands, screw-on brass pots, earth tail seals, coloured sleeving for phase identification, cone shape beads, fibre disc, brass locknuts etc. required for the proper installation work, unless otherwise approved by the S.O.'s Representative, shall be of the type manufactured by the cable manufacturer.

9.1.5.9 For mineral-insulated mineral sheathed copper conductor (MIMS) cables, termination shall be metal gland or close fitting metal bush of crimping type. All other necessary accessories such as tap-off units, joint boxes including termination kits etc. required for the proper installation work, unless otherwise approved by the S.O.'s Representative, shall be of the type manufactured by the cable manufacturer.

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9.2 WIRING IN CONDUIT/TRUNKING (SURFACE OR CONCEALED)

9.2.1 The cables used in conduit wiring, unless otherwise specified shall be similar to that described in 9.1.2 above. Unless otherwise specified in the Drawings and/or Bill of Quantities, the conduits shall be of galvanised steel and conduit fittings shall be of galvanised steel or alloy materials. Cables above false ceiling shall be run in conduit or trunking.

9.2.2 The conduit shall generally be run on the underside of the floor slab or suspended from the floor slabs by mild steel brackets or suspenders. The trunking shall be suspended from the floor slabs or mounted against the wall by mild steel brackets. The mild steel brackets shall be anti-rust treated, painted with a primer and finished in an orange enamel. The suspension structure shall be robust in constructions and adequately installed such that the conduit/trunking will not sag.

9.2.3 Conduit for lighting point shall be terminated in a junction box complete with die-cast cone-shaped metal cover so that downdrop to luminaire shall be carried out through flexible steel conduit up to the luminaire. Ceiling fan points shall be run in the similar way. Flexible conduit shall be used for termination to equipment, which are subjected to movement or vibration. However, the length of this flexible conduit shall not exceed 400mm unless approved by the S.O.'s Representative.

9.2.4 For concealed conduit wiring, a spare conduit shall be provided from the distribution board to the ceiling space for future extension. The spare conduit shall be plugged at the ceiling end with removable plug. The number of cables drawn into the conduit or laid in trunking shall be such that the ratio of the sum of the overall cross-sectional areas of the cables (including insulation and any sheath) to the internal cross-sectional area of the conduit or trunking in which they are installed shall not exceed 40% for conduit and 45% for trunking

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9.3 METALLIC AND NON-METALLIC CONDUITS

9.3.1 Steel conduits shall be of galvanised, heavy gauge, screwed type complying with MS 275-1, MS 1534:PT.1, MS 1534:PT.2:Sec1, IEC 60423, IEC 61386-1 and IEC 61386-21. All steel conduit fittings shall comply with MS 275-2, MS 1534:PT.1, MS 1534:PT.2:Sec1, IEC 61035-1, IEC 61035-2-1, IEC 61386-1 and IEC 61386-
21. The steel conduits shall be fitted with brass bushes at the free ends and expansion devices at appropriate intervals. The ends of each length of steel conduit shall be properly reamed. The termination to the distribution boards, consumer units, switchgears and outlet boxes shall be effected by brass type smooth-bore bushes. All steel conduits shall be effectively earthed.

9.3.2 For laying underground, steel conduit shall be used and buried at a minimum depth of 450mm below ground level or 100mm below floor slab or hardstanding. Junction boxes, outlet boxes etc. shall be alloy material or cast iron. The covers shall be galvanised sheet steel or alloy material with thickness not less than 1.2mm. Accessories such as junction boxes downdropping to luminaires shall have diecast cone-shaped metal cover.

9.3.3 For non-metallic conduits and fittings, they shall be of rigid high impact PVC grade Heavy Duty Code No 4421 and shall be under Product Certification Scheme. The colour of the conduit for concealed wiring shall be of orange. Unless otherwise for purposes of identification or distinguishing from another services, white coloured conduit shall be used for surface wiring. Rigid high impact PVC conduits shall comply with MS 1534:PT.1, MS 1534:PT2:Sec1, IEC 60614-1, IEC 60614-2-2, IEC 60423, BS EN 61386-2, BS EN 50086-1 and fittings shall comply with MS 1534:PT.1, MS 1534:PT2:Sec1., IEC 61035-1 and IEC 61035-2-2.

9.3.4 All fittings and accessories for the rigid high impact PVC conduits shall be made and supplied by the same manufacturer for the rigid high impact PVC conduit. The ends of each length of rigid high impact PVC conduit shall be properly reamed. The termination to the distribution boards (metalclad and all insulated), switchgears and outlet boxes shall be effected by adaptors and lock-rings. Flexible metallic and non-metallic conduits shall comply with MS 1534:PT.1, MS 1534:PT2:Sec1, IEC 60614-1, IEC 60614-2-5 and its fittings complying with MS
1534:PT.1, MS 1534:PT2:Sec1, IEC 61035-1 and IEC 61035-2- 3.

9.3.5 The conduits shall be fixed by means of saddles secured rigidly at intervals not exceeding 750mm, and within 300mm of every outlet box, junction box, device box, cabinet or fitting. Steel saddles shall be used for steel conduits. Unless otherwise specified, steel conduits and steel fittings shall be used.

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9.4 CABLE TRUNKING

9.4.1 Cable trunking system shall comply with MS IEC 61084. They shall be fabricated from galvanised sheet steel (electrogalvanised steel and/or hot dipped galvanized steel) and finished with epoxy oven baked or two coats of standard orange enamel. They shall be equipped with removable covers at suitable intervals. They shall be supplied in lengths to suit the installation and shall have the minimum wall thickness as per Table 9A: -

NOMINAL SIZE (mm x mm)	MINIMUM WALL THICKNESS (mm)
50 x 50 and below	1. 0
75 x 50 to 100 x 100	1. 2
150 x 50 to 300 x 150	1.6

Table 9A: Size and thickness for cable trunking

9.4.2 All trunking elbows, offset and combination elbows, adaptors and tees shall be of same thickness as the straight trunking and shall be the type manufactured and supplied by the same trunking manufacturer. The trunking shall be supported by fixing brackets so that the trunking will not be in contact with the walls or floor slabs. The brackets shall be installed at intervals not greater than 1500mm for vertical runs and not greater than 1000mm for horizontal runs. The brackets shall be derusted, finished in a primer and coated with standard orange enamel.

9.4.3 Wherever the trunking passes through a floor or a fire resistant wall, fire resisting barrier shall be provided. At these positions the cables shall be sealed with non-hygroscopic fire resisting material of minimum 2-hour fire rating. In addition, the floor openings and wall openings shall be sealed with similar type of compound. Cables running in the trunking shall carry conductor identification colours and shall be supported by split hard wood racks securely fixed at the base of the trunking and spaced not more than 600mm apart.

9.4.4 Cables for each final circuit shall be properly bunched together and labelled. Where conduit is tapped off from the trunking, suitable brass type smoothbore bushes shall be fitted at all conduit termination. Unless otherwise specified, all trunkings shall have either tinned copper tape of dimension not less than 25mmx3mm as circuit protective conductor or earth cable of appropriate size. In the latter case, all trunking joints shall be bridged by means of tinned copper tape of dimension not less than 25mm x 3mm.

9.4.5 For colour code identification bands can refer to table 9B of 9.7.2.

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9.5 CABLE TRAY

9.5.1 Cable tray system shall comply with MS IEC 61537 and shall be fabricated from perforated galvanised sheet steel complete with all necessary bends, tee pieces, adaptors and other accessories. The minimum thickness of the sheet steel shall be 1.5mm for cable trays with widths up to and including 300mm and 2.0mm for cable trays with width exceeding 300mm. However minimum thickness for the sheet steel of the perforated hot dipped galvanised cable trays shall be 2.0mm. Cable trays may either be suspended from floor slabs by hangers or mounted on walls or vertical structure by brackets at 600mm intervals.

9.5.2 However where the above methods of installation are not feasible or practical, suitable floor mounted mild steel structures shall be provided. All supports, hangers and structures shall be robust in construction and adequately installed to cater for the weights of the cables and trays supported on them so that cable trays and cables will not sag. All supports, hangers, bracket and structures shall be antirusted, finished in primer and coated with standard orange enamel.

9.5.3 All supports, hangers, bracket and structure for the perforated hot dipped galvanised cable trays shall also be of hot dipped galvanised type. Fixing clips and cleats for cables on trays shall be installed by means of bolts,washers and nuts.

9.5.4 All tees, intersection units, adaptor units etc. shall be the type manufactured by the cable tray manufacturer unless otherwise approved by the S.O.'s Representative. Wherever cable tray pass through a floor or a fire resistant wall, fire-resisting barrier as mentioned in 9.4.3 above shall be provided.

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9.6 CABLE LADDER

9.6.1 Cable ladder system shall comply with MS IEC 61537 and fabricated from mild steel and finished in hot-dipped galvanised complete with all necessary horizontal elbow, horizontal tee, horizontal cross, reducer straight, outside riser, inside riser, reducer left, reducer right, cable clamp, cantilever arm, hold down clip/clamp, hanger bar, vertical splice plate and horizontal splice plate for welded type and screwed type. The minimum thickness of the sheet steel shall be 2.0mm.

9.6.2 Cable ladder may either be suspended from floor slabs by hangers or mounted on walls or vertical structure by cantilever arm. Cable ladder shall be supported rigidly and adequately by external spring hangers mounted on channel base. The cable ladder shall be supported at maximum intervals of 3000mm for vertical runs and 1500mm for horizontal runs so that the cable ladder will not be in contact with the wall or floor slab surfaces. The spring hangers shall be supplied by the cable ladder manufacturer. All supports, hangers and structures shall be robust in construction and adequately installed to cater for the weights of the cables and ladder supported on them so that cable ladder and cables will not sag.

9.6.3 Rungs shall be spaced at 300mm nominal centres, welded to the rail sections by approved welding procedures. All rungs shall be perforated in accordance to the manufacturer’s design.

9.6.4 The cable ladders shall be supplied fully assembled with preparations for connections to straight sections or accessories using splice plates mechanically bolted together. Allowance shall be provided for longitutional adjustments and expansion. The cable ladders when completed shall be smooth, free from all sharp edges and shall be capable of discharging any water that may be retained due to normal weathering.

9.6.5 All accessories shall be the type manufactured by the cable ladder manufacturer unless otherwise approved by the S.O.'s Representative. Wherever cable ladder pass through a floor or a fire resistant wall, fire-resisting barrier as mentioned in 9.4.3 above shall be provided.

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9.7 IDENTIFICATION OF PIPELINES AND SERVICES

9.7.1 Unless otherwise specified elsewhere, basic colours for the identification of electrical conduits and trunkings and their coverings from other pipelines or services shall be orange for electrical services in compliance with BS 1710. For Extra Low Voltage Electrical Services, colour code indication band shall be provided. The basic identification colour shall be applied by painting over the whole length of the conduits and trunkings and their coverings.

9.7.2 However, if decorative colour white or other decorative colour is used for exposed electrical conduits and trunkings and their coverings as specified and/or as directed by S.O.'s Representative, then orange colour identification band shall be provided. In addition, for all Extra Low Voltage Electrical Services and Information Communication Technology (ICT) works, colour code indication bands shall be provided as in the Table 9B below.

Conduit / Trunking Contents	Basic Identification Colour Band (Approx. 150 mm)	Colour Code Indication Band (Approx. 100mm)
Public Address / Sound Reinforced System	Orange	Crimson
Intercom System	Orange	Emerald Green
Nurse Call / Digital Call System	Orange	Salmon Pink
MATV / CCTV System	Orange	Yellow
Building Automation / Security System	Orange	Blue
Audio Video / Data / Multimedia Link System	Orange	White / Emerald Green / white
Information Communication Technology (ICT)	White	White
Telephone System	White	Green

Table 9B : Colour Code Indications For Extra Low Voltage Electrical Services And Information Communication Technology (ICT)

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9.7.3 Colour identification bands shall be provided on the conduits and trunkings and their coverings as a band over a length of approximately 150mm. The bands shall comply to table 9B.

9.7.4 The colour identification bands and colour code indication bands shall be applied by painting or adhesive colour bands at intervals not more than 1000mm along the conduits and trunkings and their coverings. They shall be provided at junctions, both sides of service appliance, wall/floor penetration and any other place where identification is required and necessary.

The colour reference to BS 4800 shall be as in Table 9C below.

Colour	Colour Reference (BS 4800)
Orange	06 E 51
White	00 E 55
Crimson	04 D 45
Emerald Green	14 E 53
Salmon Pink	04 C 33
Yellow	10 E 53
Blue	18 E 51

Table 9C: Colour Reference

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9.8 MOUNTING HEIGHTS

9.8.1 Mounting heights listed below shall be measured from the underside of the fitting to the finished floor level. Unless otherwise specified or directed on site by the S.O.'s Representative, heights of fixing shall be as in Table 9D below: -

Type of Fitting	Mounting Height (mm)
Suspended ceiling luminaires and ceiling fans	2400
Wall mounted luminaires and wall bracket fans	2050
Switches and fan regulators	1450
Socket outlets (for surface wiring), and those in the kitchen and washing areas (for concealed wiring)	1450
Socket outlets (for concealed wiring)	300
Isolator points	1450
Window unit air conditioner switches and starters	1450
Cooker points	1450
Water heater outlet points.	1450
Distribution boards (in service duct)	1450
Distribution boards(other than in service duct)	2050

Table 9D: Mounting Height

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10.0 WIRING ACCESSORIES

10.1 SWITCHES AND SWITCH PLATES

10.1.1 All lighting switches and fan switches shall comply with MS 616 and MS IEC 60669-1 and generally be flush type. All ceiling mounted cord operated switches shall be completed with mounting block comply with MS IEC 60669-1.

10.1.2 All switches shall be suitable for use in inductive circuit. Unless otherwise specified in the Drawings and/or Bill of Quantities, they shall be rated at 10A. Samples of switches shall be submitted for approval prior to installation.

10.1.3 Switches for lighting and fans shall generally be grouped as shown in the Drawings. Where several switches are grouped together, grid switches shall be used unless otherwise directed by the S.O.'s Representative. Each group shall be of different phase and separated according to the supply source. All groups appropriately labelled.

10.1.4 Refer Table 10A below for colour scheme.

10.1.5 In areas where plate switches cannot be used, ceiling mounted cord operated switches or architrave switches shall be provided as directed by the S.O.'s Representative.

10.1.6 Maximum allowable number of switches for switch plate of size 85mm x 85mm is four (4) and maximum allowable number of switches for switch plate of size 85mm x 140mm is eight (8). Brand name and model shall be embossed at the front part of the switch plate.

10.1.7 For switches with built-in indicator light, the wiring for indicator light shall be permanently terminated and shall not used the terminal for clamping external conductors.

10.1.8 The positions of all switches shown in the Drawings are only approximate. The Electrical Contractor should check the exact positions of the switches with the S.O.'s Representative, and confirm the arrangement of all door swings and other fixtures before installing downdrops and switches.

10.1.9 The circuit protective conductor of the circuit shall terminate directly at the earth terminal of the mounting box (back box).

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Connected From		Normal	Generator Set	UPS
Switched Socket Outlets And Switches	Rocker	White	Yellow	Red
	Face Plate	White	White	White
Unswitched Socket Outlets	Face Plate	White	Yellow	Red

Table 10A: Colour Scheme for Switches and Socket Outlet

10.2 SWITCHED SOCKET OUTLETS AND UNSWITCHED SOCKET OUTLETS

10.2.1 Switched socket outlets shall be shuttered, two pole or single pole switch and earthing pin type. They shall be of flush type. Both 13A switched and unswitched socket outlet shall be of the rectangular pin type complying with MS 589.

10.2.2 15A switched socket outlets and unswitched socket outlets shall be of round pin type and comply with MS 1577.

10.2.3 Circuit protective conductor of the circuit shall terminate directly at the box used for mounting switched socket outlet and unswitched socket outlet.

10.2.4 Refer Table 10A for colour scheme.

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10.3 BOXES FOR SWITCHES, SWITCHED SOCKET OUTLETS, UNSWITCHED SOCKET OUTLETS AND DISTRIBUTION BOARDS (BOX AND ENCLOSURE FOR ELECTRICAL ACCESSORIES)

10.3.1 Generally the boxes shall comply with MS 1873, IEC 60670-1, MS 589 and /or MS 616.

10.3.2 Unless otherwise specified, boxes used for mounting switch plates, switched socket outlets and unswitched socket outlets in concealed conduit wiring shall be metalclad type of minimum 0.8mm thick galvanised sheet steel. Earth terminal complete with cable lug and brass screw shall be provided. Cable for bonding the box to switch, switched socket outlet and unswitched socket outlet shall be the same size as the circuit protective conductor.

10.3.3 For surface conduit wiring, boxes for switches, switched socket outlets and unswitched socket outlets shall be of the type manufactured and supplied by the manufacturer of the switch plates, switched socket outlets and unswitched socket outlets respectively.

10.3.4 Switch plates, switched socket outlet and unswitched socket outlets shall be fixed to the boxes by means of original flat base chrome screws.

10.3.5 The installations of Distribution Boards on the walls (as classified according to some parts of MS 1873, IEC 60670-1) shall comply with MS 1873 Part 24, IEC 60670-24. Flushed adaptable metal back box of minimum size 200mm(W) x 100mm(H) x 35mm(D) shall be installed recessed behind Distribution Boards for rewirebility.

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10.4 CEILING ROSES

10.4.1 Ceiling Roses shall comply with MS 770. They shall be either surface of semi-recess type with the base having a minimum of three knockouts for cable entries. The base shall incorporate clearly labelled clamp type terminals suitable for holding phase, neutral, earth and loop-in cables in a distinct manner. The cover plates shall be of the screw-in type. The base and cover shall be moulded non-track urea to BS 1322.

10.5 LAMPHOLDERS AND BATTENHOLDERS

10.5.1 Lampholders and battenholders shall comply with MS 769, MS IEC 60838, and MS IEC 61184. They shall be supplied complete with brass plunger and heat resisting springs to ensure that plunger pressure is maintained throughout the long life of the lampholders and battenholders. Cordgrip shall be provided to cover the exposed ends of cord sheathing and firmly grips the cord. Batten holders shall be of three clearly labelled terminal type. Edison screw lampholders shall comply with MS IEC 60238.

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11.0 LUMINAIRES

11.0.1 The luminaires together with lamp, lamp holders, control gear and other associated accessories shall, as a minimum requirement, conform to the relevant parts and/or sections of MS IEC 60598.

11.0.2 All luminaires shall be fully assembled, completed with lamp, control gear, internal wiring etc.. Internal wires shall be terminated in terminal blocks in an approved manner. Wiring shall be of heat resistant insulated coloured cables. The terminal blocks shall be suitably rated and clearly labeled for connection to external wiring.

11.0.3 All metal parts of the luminaires shall be effectively earthed and supplied with an approved earth terminal.

11.0.4 All components of the luminaires shall be able to withstand a voltage range of +10% to -6% of the rated voltage.

11.0.5 All discharge type luminaires shall be power factor corrected to at least 0.9 lagging using dry type capacitor.

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11.1 FLUORESCENT LUMINAIRES

11.1.1 TUBULAR TYPE FLUORESCENT LUMINAIRES

11.1.1.1 Fluorescent luminaires shall be of the type approved by Suruhanjaya Tenaga and JKR.

11.1.1.2 Fluorescent luminaires shall comply with MS IEC 60598-1 and MS IEC 60598-2-1 or MS IEC 60598-2-2.

11.1.1.3 Fluorescent luminaires shall have housing made from good quality mild steel sheet of minimum thickness 0.50 mm and shall be of sound and rigid construction suitable for suspended and surfaced mounted installation. The metalwork shall be rust inhibited to prevent corrosion and, unless otherwise approved by the S.O.'s Representative, shall be sprayed with an undercoat of zinc chromate primer and finished with two coatings of super white baked enamel.

11.1.1.4 Wiring within the luminaire shall be carried out with heat resistant cable marked with the word “HR 105°C ". It shall be done in a neat way with holder to hold the cable in position and also to avoid contact with heat producing components. Cables shall be terminated in a termination block marked ”L" and “N" for connection to the incoming wires. A brass direct pressure type earth terminal shall be provided in the casing near the termination block for earth connection. This earth terminal shall be clearly marked with the standard earth terminal symbol.

11.1.1.5 All components in the luminaire shall be guaranteed for a minimum of 2000 hour life. All components in the fluorescent luminaires shall be manufactured by the manufacturer or being supplied by others. The components shall be marked with “made for” if supplied by other manufacturer except high frequency electronics ballast if specified, fluorescent tube, starter, cable and holders for fluorescent tube and starter. The components shall be of the type approved by Suruhanjaya Tenaga and JKR.

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11.1.1.(a) TUBULAR TYPE FLUORESCENT LUMINAIRES T8 (FD 26)

11.1.1.(a).i The electromagnetic ballast shall comply with MS IEC 61347-1, MS IEC 61347-2-8 and MS 141:PT.2. The ballast shall be of the type approved by Suruhanjaya Tenaga and JKR. Unless otherwise specified, they shall be polyester resin impregnated, silent operation type fitted with terminal block for easy wiring. For 18 watts and 36 watts fluorescent tubes, the watt loss of the ballast shall be 6 watts. The mounting of the ballast shall be in such a way that easy dismantling and replacement can be effected within the casing.

11.1.1.(a).ii The fluorescent luminaires shall be power factor corrected to at least 0.9 lagging.

11.1.1.(a).iii The capacitor shall comply with MS IEC 61048 and MS IEC 61049 and shall be of dry, self-healing, aluminium metalised polypropylene type. Proper tool clip shall be provided to hold the capacitor in position.

11.1.1.(a).iv The starter shall comply with MS IEC 60155 and the starter holders comply with MS IEC 60400. For the single channel luminaires, the starter shall be fitted at the side of the casing. In cases where starters are to be fitted from the outside of the luminaire casing, the starter holders shall be installed in such a way that the starters shall not protrude out of the casing by more than 10mm.

11.1.1.(a).v In the case where high frequency electronics ballast is specified, the ballast shall be of type approved by Suruhanjaya Tenaga and JKR. The ballast shall comply to MS IEC 61347-1, MS IEC 61347-2-3 and MS IEC 60929, BS EN 55015 for radio frequency interference suppression and MS IEC 61000-3-2 for harmonics distortion. They shall be of preheat start, non-dimming, low in-rush starting current and low leakage current type. Rated maximum operating temperature of a ballast case shall not exceed 70 ^{o}C. The Ballast shall be rated a minimum Energy Efficiency Index Classification (EEI) of A2 as per CELMA/ELC Guide.

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11.1.1.(a).vi Harmonics distortion shall be within the limits in accordance with MS IEC 61000-3-2. However, total harmonics distortion shall be less than 25% where third harmonics component shall not be more than 15%.The ballast shall operate and maintain consistent light output over voltage variation from -10% to +5% of the rated voltage and power factor of not less than 0.95. Overvoltage protection at 350 volts and automatic shutdown in the event of lamp failure shall also be incorporated. The electronic ballast shall have five year warranty from the manufacturer.

11.1.1.(a).vii The lamp holders shall comply with MS IEC 60400 of robust and well designed construction suitable for bi-pin fluorescent tubes. The lamp holders shall be made of polycarbonate material. Lamp holders for use with electronic ballast shall be rated minimum 500V or higher than U-out rating of electronic ballast, (whichever is higher).

11.1.1.(a).viii All fluorescent tube shall be provided with its own ballast (except for electronic ballast).

11.1.1.(a).ix Louvres and reflectors for the luminaires shall be made of high purity anodized aluminium with at least 99.85% pure aluminium with no iridescent mirror finished. The thickness of the reflector shall be minimum 0.4mm and total light reflection of reflector shall be minimum 86%.

11.1.1.(a).x The prismatic and opal diffuser shall be made of Ultra Violet (UV) stabilised Flame Retardant Polyethylene Terephtalate Glycol (PETG) or minimum UV-stabilised flame retardant material.

11.1.1.(a).xi Louvres, reflectors and diffusers shall give good even light distribution with minimal glare in both the axial and transverse planes. Photometric data for the luminaires shall be made available and submitted to S.O."s Representatives when required.

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11.1.1.(b) TUBULAR TYPE FLUORESCENT LUMINAIRES T5 (FDH 16)

11.1.1.(b).i The high frequency electronics ballast shall be of type approved by Suruhanjaya Tenaga and JKR. The ballast shall comply to MS IEC 61347-1, MS IEC 61347-2-3 and MS IEC 60929, BS EN 55015 for radio frequency interference suppression and MS IEC 61000-3-2 for harmonics distortion. They shall be of preheat start, non-dimming, low in-rush starting current and low leakage current type. Rated maximum operating temperature of a ballast case shall not exceed 70^{U}C. The Ballast shall be rated a minimum Energy Efficiency Index Classification (EEI) of A2 as per CELMA/ELC Guide.

11.1.1.(b).ii Harmonics distortion shall be within the limits in accordance with MS IEC 61000-3-2. However, total harmonics distortion shall be less than 25% where third harmonics component shall not be more than 15%.The ballast shall operate and maintain consistent light output over voltage variation from -10% to +5% of the rated voltage and power factor of not less than 0.95. Overvoltage protection at 350 volts and automatic shutdown in the event of lamp failure shall also be incorporated. The electronic ballast shall have five year warranty from the manufacturer.

11.1.1.(b).iii The lampholders shall comply with MS IEC 60400 of robust and well designed construction suitable for bi -pin fluorescent tubes. The lamp holders shall be made of polycarbonate material. Lamp holders shall be rated minimum 500V or higher than U-out rating of electronic ballast, (whichever is higher).

11.1.1.(b).iv Louvres and reflectors for the luminaires shall be made of high purity anodized aluminium with at least 99.85% pure aluminium with no iridescent mirror finished. The thickness of the reflector shall be minimum 0.4mm and total light reflection of reflector shall be minimum 90%.

11.1.1.(b).v The prismatic and opal diffuser shall be made of Ultra Violet (UV) stabilised Flame Retardant Polyethylene Terephtalate Glycol (PETG) or minimum UV-stabilised flame retardant material.

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11.1.1.(b).vi Louvres, reflectors and diffusers shall give good even light distribution with minimal glare in both the axial and transverse planes. Photometric data for the luminaires shall be made available and submitted to S.O."s Representatives when required. For luminaires T5 cross louvre type, the Light Output Ratio (LOR) shall be minimum 80%.

11.1.2 DOWNLIGHT TYPE COMPACT FLUORESCENT LUMINAIRES

11.1.2.1 The luminaires shall be of type approved by JKR. The luminaires shall comply with MS IEC 60598 and relevant part of IEC 60598 or equivalent.

11.1.2.2 The luminaires shall have two separate components comprising of an electrical control gear and optical systems. The construction of the luminaires shall be either in two separate housing/compartment or integral.

11.1.2.3 Electrical control gear system comprises of ballast, capacitor etc. The optical system shall incorporate a one piece full bowl reflector, lamp holder(s) etc. Luminaires shall have either horizontal or vertical pin type lamp connection.

11.1.2.4 The housing of the control gear system shall be made from extruded aluminium or good quality mild steel sheet of thickness not less than 0.8 mm and shall be of sound and rigid construction suitable for suspended installation. The metalwork shall be rust inhibited to prevent corrosion. The housing of the control gear system shall be coated by electrostatic powder. The housing shall be provided with a mean to dissipate heat. Rubber grommets shall be provided at cable entry.

11.1.2.5 Wiring within the control gear system shall be carried out with heat resistant cable marked with the word 'HR 105 ^{o}C'. It shall be done in a neat way with holder to avoid contact with heat-producing components. Cables shall be terminated in a termination block marked 'L' and 'N' for connection to the incoming wires. A brass direct pressure type earth terminal shall be provided in the control gear near the termination block for earth connection. This earth terminal shall be clearly marked with the standard earth terminal symbol. The HR 105 ^{o}C cable shall be used to connect the optical system and the control gear system. It shall not be more than 300mm long. The cables shall be enclosed in a cable sleeve HR 105 ^{o}C.

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11.1.2.5.1 Electrical connection and disconnection of the control gear system from the incoming supply cables and optical system shall be through a plug & socket/connection unit. It shall be made from flame retardant material. The plug & socket shall be rated at 10A. A conduits fitting that terminates the flexible conduit to the lamp control gear shall be provided. The cable clamp arrangement shall not damage the insulation of the cables.

11.1.2.5.2 The manufacturer shall provide installation instruction for each model of the luminaries by means of hook or other suitable method.

11.1.2.6 The reflector shall be made of high purity anodized aluminium with at least 99.85% pure aluminium with no iridescent mirror finished (e.g. polished aluminium). The thickness of the reflector shall be minimum 0.5 mm. The support shall be made from mild steel with minimum thickness of 1.3 mm. The ring shall be made from die-cast aluminium with minimum thickness of 1.3 mm. The support and ring shall be coated by electrostatic powder. The clip shall be made from stainless steel. For horizontal lamp connection, the diameter of the reflector shall be large enough for easy relamping of lamps.

11.1.2.6.1 Photometric data for the luminaires shall be made available and submitted to S.O.'s Representatives when required. The required photometric data for the luminaires shall be Polar Curve, Utilization Factors, Luminance Distribution Table, Downward Light Output Ratio, Upward Light Output Ratio, Light Output Ratio, Spacing to Mounting Height Ratio and Threshold Increment.

11.1.2.6.2 Light Output Ratio for the luminaires shall be minimum 70%.

11.1.2.7 The lamp holder shall be G24 type for the 10W/13W/18W/26W compact fluorescent lamp (CFL) without integral control gear. The lamp holder shall comply with MS IEC 60400, made to fit individual lamp wattage and not interchangeable. The lampholder shall be made of non-metallic, heat resistant material and be rigidly fixed onto the optical compartment. The lampholder shall be incorporated with a housing made from extruded aluminium or good quality mild steel sheet or aluminium die cast with a mechanism to dissipate heat (heat sink).

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11.1.2.8 The ballast shall comply with MS IEC 61347-1, MS IEC 61347-2-8 and MS 141: PT.2 and shall be of the type approved by Suruhanjaya Tenaga and JKR. The ballast shall be polyester resin impregnated, silent operation type fitted with terminal block for easy wiring. The watt loss for the ballast shall be 6W.

11.1.2.8.1 For electronic ballast refer to 11.1.1.(a).v

11.1.2.9 The capacitor shall comply with MS IEC 61048 and MS IEC 61049 and of type approved by Suruhanjaya Tenaga and JKR. The capacitor shall be cylinder shape type. The capacitor shall be dry, self healing, metalised polypropylene type with terminal block for easy wiring.The casing shall be made from aluminium or flame retardant plastic. The capacitor shall be mounted with nut and lock washer.

11.1.2.10 All components in the fluorescent luminaires shall be manufactured by the manufacturer or being supplied by others. The components shall be marked with “made for” if supplied by other manufacturer except high frequency electronics ballast if specified, compact fluorescent lamp, cable and holders for compact fluorescent lamp. The components shall be of the type approved by Suruhanjaya Tenaga and JKR.

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11.2 SELF CONTAINED LUMINAIRES

11.2.1 Self-contained emergency luminaires shall comply with MS 619 and IEC 60598-2-22 and approved by Jabatan Bomba Dan Penyelamat Malaysia and JKR.

11.2.2 The body shall be made from good quality mild steel sheet, aluminum extrusions or injection moulded flame retardant material. For mild steel sheet, shall be rust inhibited to prevent corrosion. The body shall be sprayed with an undercoat of zinc chromate primer and finished with two coatings of super white baked enamel.

11.2.3 The diffuser shall be of flame retardant type. The material for the diffuser shall be of either polycarbonate or prismatic Polyethylene Terephthalate Glycol (PETG) or equivalent.

11.2.4 The luminaires shall be equipped with maintenance-free high temperature rated sealed nickel cadmium battery, solid state automatic charger, changeover device, fluorescent lamp, indicator lamp, test switch and interior disconnecting device i.e. fuse, relay or other protective device. Other types of battery shall be allowed provided they conform to their relevant safety and performance standard and the relevant requirement of MS 619 and IEC 60598-2-22.

11.2.5 The battery shall be fully rechargeable to its operational capacity in not more than 24 hours after discharge. Low volt cut-off safety feature shall be incorporated to prevent over discharge of battery. The response time for non-maintained emergency luminaires shall be 2 second upon failure of the normal lighting.

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11.2.6 Unless otherwise specified, the fluorescent tube shall be 8 watt with minimum output of 330 lumen. The duration for emergency operation shall not be less than 3 hours. The initial lumen output of the self-contained emergency luminaires at changeover from normal to emergency mode shall be not less than 25% of the nominal lumen output of the fluorescent tube. The lumen output at the end of the rated duration shall be minimum 10% of the nominal lumen output of the fluorescent tube.

11.2.7 The self contained emergency luminaires with “KELUAR” signage pictogram shall be of the maintained 3 hours rating type as specified above, complying with relevant part of MS 983, MS 619 and IEC 60598-2-22 and approved by Jabatan Bomba Dan Penyelamat Malaysia and JKR. The lamp shall be of 2 fluorescent tubes type or minimum 10 units of super bright white LEDs. The diffuser shall be of flame retardant type. The material for the diffuser shall be of either polycarbonate or prismatic PETG or equivalent. The lettering and directional arrow shall be white on green background.

11.2.8 The LED shall face downward to provide uniform light distribution via the transparent acrylic on “KELUAR” signage pictogram and to provide courtesy light source at the floor level for increase safety. The LED shall comply to the following characteristics:

	Module Type	
Characteristics	Dot Matrix	
Operating Voltage	230V (+10%, -6%), 50Hz +1%	
Power Factor	≥ 0.90	
Total Harmonic Distortion	≤ 20 %	
Power	8 W – 10 W (Typical : 10 W)	
Intensity	200cd – 800cd	
LED type	5 mm (AlInGaP, InGaN)	
LED Mounting Technology	Through holes	
Chromaticity Coordinates (x , y) as on CIE chart	White	Green
	0.361 , 0.385 0.264 , 0.267 0.280 , 0.250 0.356 , 0.350	0.009 , 0.720 0.284 , 0.520 0.209 , 0.400 0.028 , 0.400

Table 11A: Electrical Characteristics of LED signal module

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11.3 LED LUMINAIRES

11.3.1. DOWNLIGHT TYPE LED LUMINAIRES

11.3.1.1. The luminaires shall be of type approved by Suruhanjaya Tenaga (ST).

11.3.1.2. The luminaires shall comply with the relevant Malaysian Standards or IEC Standards and other relevant standards in terms of safety and performance criteria. The luminaires shall comply to MS IEC 60598 Series, IES LM-79-08, IES LM-80-08, MS 62722-2-1, MS IEC 62031, IEC 62471, IEC 61547, MS IEC 61000-3-2 and BS EN 55015 / CISPR 15.

11.3.1.3. The luminaires shall be designed and constructed that it is capable of providing the service for which is intended. It shall be manufactured under "Lighting Class LED" and shall be commercially available.

11.3.1.4. The LED luminaires shall be new and complete with LED control gear (LED driver), thermal management unit, surge and overvoltage protection and suitable for supply voltage of 230 V, +10%, -6% at 50 Hz. The LED luminaire shall consist of two separate components comprising of LED control gear and optical system.

11.3.1.4.1 The construction of the luminaires shall be of either two separate housing / compartments or integrated.

11.3.1.4.2 The luminaire shall be shined downwards to provide uniform light distribution and it shall have adequate heat sink for heat dissipation / thermal management.

11.3.1.4.3 All components of the luminaires shall operate well within the ratings with due consideration for the local conditions (high humidity of 95% RH and ambient temperature of 35°C).

11.3.1.4.4 Interchangeability of consumable components is preferred for maintenance purposes.

11.3.1.4.5 The luminaires in mode of operation shall not produce voltage disturbance / fluctuation to the electrical supply system.

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11.3.1.4.6 The housing of the LED control gear and optical system shall be of sound and rigid construction suitable for suspended installation. A means of connecting the flexible GS conduit to the lamp control gear / luminaires shall be provided.

11.3.1.4.7 Material used for the construction of the luminaires and its component shall be recyclable.

11.3.1.5. The LED control gear shall comply to MS IEC 61347-2-13, MS IEC 62384, BS EN 55015 / CISPR 15 for radio frequency interference suppression and MS IEC 61000- 3-2 for harmonics distortion. Rated maximum operating temperature of the LED control gear shall not exceed 70°C.

11.3.1.5.1 Harmonics distortion shall be within the limits in accordance with MS IEC 61000-3-2. However, total harmonics distortion shall be less than 20%. The LED control gear shall operate and maintain consistent light output over voltage variation from +10% to -6% of the rated voltage and power factor of not less than 0.9 lagging.

11.3.1.5.2 The LED control gear shall be able to withstand short circuit current, overload, over voltage, under voltage and over temperature.

11.3.1.5.3 The optical system shall incorporate one piece full bowl reflector where applicable and high power LED or LED module of required wattage and shall comply to MS IEC 62031 and IEC 62471. The luminaire shall continue to operate safely even though there is failure of a partial number of LEDs / LED. The LEDs / LED module lumen output shall not be depreciated to below 70% of the original output during the liability / warranty / contract period (whichever is applicable). The initial luminous flux shall not be less than 90% of the rated luminous flux.

11.3.1.5.4 There shall be no flickering of the light source in mode of operation and when it reaches its end of life.

11.3.1.5.5 The LED / LED module shall not be driven more than the rated drive current.

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11.3.1.6. The optical system support shall be made from mild steel / die cast aluminum with minimum thickness of 1.3 mm . The ring shall be made from die-cast aluminum with minimum thickness of 1.3 mm. The support and ring shall be coated with electrostatic powder. The clip shall be made from stainless steel.

11.3.1.6.1 The optical system shall comprise of optical lens reflector and glass diffuser (if applicable). It shall give good even light distribution with minimal glare in both the axial and transverse planes.

11.3.1.6.2 When applicable, the reflector shall be made of high purity anodized aluminium with at least 99.85% pure aluminium with low iridescent / iridescent free mirror finished(e.g.polished aluminium). The thickness of the reflector shall be minimum 0.5 mm.

11.3.1.6.3 Photometric data for the luminaires shall be made available and submitted. The required photometric data for the luminaires shall be Polar Curve, Utilization Factor, Luminance Distribution Table, Downward Light Output Ratio, Upward Light Output Ratio, Light Output Ratio and Spacing to Mounting Height Ratio.

11.3.1.7. Connection cables shall be terminated in a termination block marked 'L' and 'N' for connection of the incoming wires. For Class 1 Luminaires, a brass direct pressure type earth terminal shall be provided in the LED driver system near the termination block for earth connection. This earth terminal shall be clearly marked with the standard earth terminal symbol.

11.3.1.7.1 For separated optical and LED control gear, electrical connection of the LED control gear and optical system shall be through a plug and socket (i.e. male / female connection unit) It shall be made from non-flammable material and shall be rated at 10A. It shall comply to MS IEC 60838-2-2.

11.3.1.7.2 Heat Resistant (HR) 105˚C cable shall be used to connect the optical system and LED control gear and shall be of stranded type. It shall not be more than 300 mm long. The cable shall be enclosed in a cable sleeve HR 105˚C.

11.3.1.7.3 Wiring shall be done in a neat way to avoid contact with heat producing components. A means of clamping the electrical cable shall be provided. The cable clamp arrangement shall not damage the insulation of the cables.

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11.3.1.7.4 Where optical and control gear system are not integrated, both the optical and control gear system shall be provided with hooks or other suitable means for hanging purposes.

11.3.1.8. The LED Downlight shall comply to the following characteristic:

Characteristic	Description		
Light Source	Lighting Class LED		
Power Supply	230V +10, -6%, 50Hz		
Correlated Colour Temperature (CCT)	2700K,3000K, 3500K	4000K, 4500K	5000K,6500K
Colour Rendering Index	≥ 80	≥ 80	≥ 80
Lumens	≥ 850	≥ 850	≥ 950
Luminaire Efficacy	≥ 75lm/W	≥ 75lm/W	≥ 75lm/W
Beam Angle	≥ 60˚		
Power Consumption	≤ 20W		
Power Factor	≥ 0.90		
Ambient Temperature	-20˚C to 35˚C		
Rated Lifetime	≥ 50,000 hours, 70% lumen maintenance at Ta=25˚C		
LED Photobiological Safety Class	Exempt group (IEC 62471)		
Total Harmonic Distortion (THD)	≤ 20%		

Table 11.4.1: Characteristics of LED Downlight

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11.3.1.9. The manufacturer shall provide a minimum 5 years period warranty certificate as stated in the defect liability / warranty / contract period (whichever is applicable) for the complete luminaire to guarantee the long life expectancy and maintenance-free luminaire. Warranty declaration shall be filled and signed by manufacturer. Failure in the functioning and operation of the LED luminaire within the warranty period will result in the replacement of the whole luminaire or required components by the manufacturer at no cost to the JKR.

11.3.1.10. Illuminance test shall be carried out every 6 months during defect liability / warranty / contract period (whichever is applicable) to ensure the performance of the installed system conform to the design requirement as per JKR specifications. This test shall also confirm the lumen maintenance of the luminaire.

11.3.1.10.1 The luminaire manufacturer shall provide calibrated illuminance meter and have the capacity and competency to carry out the illuminance test during the testing of the installed lighting system.

11.3.1.11. **Conformity with Standards**

The LED luminaire shall comply with and be tested to the relevant latest edition of Malaysia Standard or other relevant international standard as below:

Item	Criteria	Relevant Standard
Safety & construction	Luminaire	**MS IEC 60598-1** Luminaires – Part 1: General requirements and tests
		MS IEC 60598-2-1 Luminaires. Part 2: Particular requirements. Section One: Fixed general purpose luminaires
		MS IEC 60598-2-2 Luminaires. Part 2: Particular requirements, Part 2 - Section 2: Recessed luminaires
Safety & construction	LED driver	**MS IEC 61347-1** Lamp control gear – Part 1: General and safety requirements

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Item	Criteria	Relevant Standard
Safety & construction		**MS IEC 61347-2-13** Lamp control gear- Part 2-13 – Particular requirement for d.c or a.c supplied electronic controlgear for LED modules.
	LED module	**MS IEC 62031** LED modules for general lighting – Safety specifications
Safety	Lamp holder	**MS IEC 60838-2-2** Miscellaneous lampholders – Part 2-2 – Particular requirements – connectors for LED modules
Safety	LED lamps/module (eye protection)	**IEC 62471** Photobiological safety of lamps and lamp systems
Performance	LED driver	**MS IEC 62384** DC or AC supplied electronic control gear for LED modules – Performance requirements
	LED Luminaires	**MS 62722-1** Luminaire Performance - Part 1: General Requirements
		MS 62722-2-1 Luminaire Performance - Part 2-1: Particular Requirements for LED Luminaires

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Item	Criteria	Relevant Standard
Performance	Photometric	**IES LM-79-08** Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products
	LED Light Source (*by LED Manufacturer)	**IES LM-80-08** Approved Method: Measuring Lumen Maintenance of LED Light Sources
	LED Light Source (*by LED Manufacturer)	**IES TM 21-11** Projecting Long Term Lumen Maintenance of LED Light Sources
Safety	EMC	**IEC 61547** Equipment For General Lighting Purposes-EMC Immunity Requirements
		IEC 61000-3-2 ELECTROMAGNETIC COMPATIBILITY (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤16 A per phase)
Performance		**CISPR 15 (BS EN 50015)** Limits and Methods of Measurement of Ratio Disturbance Characteristics of Electrical Lighting And Similar Equipment

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11.4 INSTALLATION OF LUMINAIRES

11.4.1 For luminaires with pendant lampshade, the wiring shall terminate in ceiling rose. Connection from ceiling rose to lamp holder in the luminaire shall be by 3 core flexible cord of not less than 0.75 sq. mm. The flexible cord may be used for suspending the luminaires if the total mass of the luminaire does not exceed 2 kg. If the mass of the luminaires exceeds 2kg, a hook shall be installed and the luminaire shall be suspended from the hook by means of decorative chain approved by the S.O.'s Representative.

11.4.2 For ceiling mounted and wall mounted luminaires, the wiring shall terminate directly into terminal block in the luminaires or into a batten lampholder as the case may be.

11.4.3 For luminaires to be recessed into suspended false ceiling, wiring shall run through junction box and flexible steel conduit right up to the luminaires as described in 9.2. The luminaires shall not sit on the ceiling structure but shall be securely suspended from the floor slabs or beams of roof trusses by means of suspension rods, brass chains or galvanised steel wires of minimum size 1.6mm diameter or as specified or as directed by the S.O.'s Representative.

11.4.4 Downlight type fluorescent luminaires shall be suspended from the floor slabs. Where optical and control gear system are not integrated, both the optical and control gear system shall be provided with hooks, galvanised steel wires of minimum size 1.6mm diameter and necessary accessories or as specified or as directed by the S.O.'s Representative. The luminaires shall not sit on the ceiling structure but shall be securely suspended from the floor slabs or beams of roof trusses.

11.4.5 Openings required for recessing the luminaire of item 11.4.3 and 11.4.4, shall be done by the Main Contractor. However the Electrical Contractor shall provide all details to the Main Contractor.

11.4.6 Where fluorescent luminaires are to be surface mounted on the underside of soft board or other type of ceilings which is combustible, suitable spacers shall be inserted between the base of the luminaires and the ceiling such that a minimum clearance of 10mm exists between the luminaires and the ceiling.

11.4.7 Where fluorescent luminaires are to be suspended from ceiling of floor slab, suitable suspension rods shall be provided. The wiring shall be terminated into a terminal block in the suspension channel. Connection from the terminal block to the luminaires shall be by 3 core flexible cord as mentioned above. The flexible cord shall be concealed inside the suspension assembly.

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12.0 LAMPS

12.1 TUBULAR FLUORESCENT LAMP

12.1.1 The tubular fluorescent lamp shall comply with MS IEC 60081 and MS IEC 61195 and shall be bi-pin type. The lamp characteristic shall be as per Table 12A:

Nominal Diameter (mm)	Nominal Length (mm)	Power (W)	Base	Min. lumens (after 100 hrs/25°C)	Nominal Colour Temp (Kelvin)	Colour Rendering Index (Ra)	ILCOS code	Proprietary Code	Rated Lifespan (hrs)
26	600	18	G13	1300	4000 & 6500	80 -89	FD	T8	10,000
26	1200	36	G13	3250	4000 & 6500	80 - 89	FD	T8	10,000
16	550	14	G5	1100	4000 & 6500	80 - 89	FDH	T5	20,000
16	550	24	G5	1700	4000 & 6500	80 - 89	FDH	T5	20,000
16	1150	28	G5	2400	4000 & 6500	80 - 89	FDH	T5	20,000
16	1150	54	G5	4150	4000 & 6500	80 - 89	FDH	T5	20,000

Table 12A : Lamp Characteristics for Tubular Fluorescent

12.2 COMPACT FLUORESCENT LAMP WITHOUT INTEGRAL CONTROL GEAR

12.2.1 The compact fluorescent lamp without integral control gear shall comply with IEC 60901 and IEC 61199 and shall be 2/4-pin type and of 2/4-limb and shall be rated for 8000 hours life at rated voltage. The lamp characteristic shall be as per Table 12B.

Power (watt)	Base	Min. lumens (after	Nominal Colour Temperature (Kelvin)	Colour Rendering Index (Ra)	ILCOS code
10	G24d-1/ G24q-1	600	4000	80 -89	FSQ
			6500		
13	G24d-1/ G24q-1	900	4000	80 - 89	FSQ
		855	6500		
18	G24d-2/ G24q-2	1200	4000	80 - 89	FSQ
		1130	6500		
26	G24d-3/ G24q-3	1800	4000	80 - 89	FSQ
		1700	6500		

Table 12B: Lamp Characteristics for Compact Fluorescent

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12.3 COMPACT FLUORESCENT LAMP WITH INTEGRAL CONTROL GEAR

12.3.1 The compact fluorescent lamp with integral control gear shall comply with IEC 60968 and IEC 60969, and shall be of E14 or E27 screw type base and shall be guaranteed for 10000 hours life at rated voltage. Unless otherwise specified, they shall have an outer cylindrical or spherical diffusing bulb.

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12.4 LED LAMP

12.4.1 LED BULB

12.4.1.1 The bulb shall be of type approved by Suruhanjaya Tenaga (ST) . The bulb shall comply with the relevant Malaysian Standards or IEC Standards and other relevant standards in terms of safety and performance criteria. The bulb shall comply to MS IEC 62560, MS 62722, IES LM-79 -08, IES LM-80-08, IEC 62471, MS IEC 60061 Series, MS 62612, IEC 61547, MS IEC 61000-3-2, BS EN 55015 or CISPR 15 and fit to luminaires that comply to MS IEC 60598 Series.

12.4.1.2 The bulb shall be designed and constructed that it is capable of providing the service for which is intended. It shall be manufactured under “Lighting Class LED” and shall be commercially available.

12.4.1.3 The bulb shall be designed and manufactured to suit with existing available lamp holder that fits lamp cap as per standard IEC 60061 (e.g. E27 / E26 and GU5.3 (MR16)). The housing of the bulb shall be made from aluminum, polycarbonate or other material that sufficiently proven to resistant to heat and flame. Material used for the construction of the bulb shall be recyclable.

12.4.1.3.1 For self ballasted LED bulb (e.g. E26 / E27 and GU5.3), the bulb shall be manufactured as a unit which cannot be dismantled without being permanently damaged, non- repairable and factory-sealed unit. It shall be provided with a lamp cap and incorporating a LED light source, LED control gear (LED driver) and any additional elements necessary for stable operation of the light source.

12.4.1.3.2 For non self-ballasted LED bulb (e.g. for GU5.3), the LED control gear (LED driver) shall comply to MS IEC 61347-2- 13, MS IEC 62384, IEC 61547, BS EN 55015 or CISPR 15 for radio frequency interference suppression and MS IEC 61000-3-2 for harmonics distortion. The Insulation protection shall be of Class II. Rated maximum operating temperature of the LED control gear (LED driver) shall not exceed 70°C. The connection system shall comply to MS IEC 60838-2-2. LED module shall comply to MS IEC 62031 and shall be of the type approved by Suruhanjaya Tenaga (ST).

12.4.1.4 The bulb shall be new and totally enclosed. The beam angle shall be as specified / requirement of the intended application.

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12.4.1.5 The bulb shall be complete with thermal management unit (heat sink), surge and overvoltage protection and suitable for supply voltage of 230V, +10%, -6% at 50Hz with power factor corrected to at least 0.9 lagging and shall not produce voltage disturbance / fluctuation to the electrical supply system.

12.4.1.5.1 The bulb shall operate well within the ratings with due consideration for the local conditions (high humidity of 95% RH and ambient temperature of 35°C)

12.4.1.5.2 Harmonics distortion for LED control gear shall be within the limits in accordance with MS IEC 61000-3-2. However, total harmonics distortion shall be less than 20%. The LED driver shall operate and maintain consistent light output over voltage variation from +10% to -6% of the rated voltage and power factor of not less than 0.9 lagging.

12.4.1.6 The LED luminous flux output of LED light source shall not be depreciated to below 70% of the original output during life hours. The initial luminous flux shall not be less than 90% of the rated luminous flux.

12.4.1.7 The LED module shall not be driven more than the rated LED drive current.

12.4.1.8 The bulb which incorporating multiple numbers of LEDs or LED modules shall continue to operate even though there is failure of a partial number of LEDs or LED modules.

12.4.1.9 Photometric data for the bulb shall be made available. The required photometric data for the bulb shall be Polar Curve, Utilization Factor, Luminance Distribution Table, Downward Light Output Ratio, Upward Light Output Ratio, Light Output Ratio and Spacing to Mounting Height Ratio.

12.4.1.10 The lamp caps interchangeability shall comply to MS IEC 60061. The bulb shall come into its intended position with no permanent deformation when inserted into lamp holder and shall be capable of easy and correct positioning by the user. The bulb shall not be fall apart from its cap in any mounting / burning position.

12.4.1.11 The manufacturer shall provide a minimum 5 years period warranty certificate as stated in the defect liability / warranty / contract period (whichever is applicable) for the complete bulb to guarantee the long life expectancy and maintenance free bulb. Warranty declaration shall be filled and signed by manufacturer. Failure in the functioning and operation of the LED luminaire/lamp within the warranty period will result in the replacement of the whole luminaire or required components by the manufacturer at no cost to the government.

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12.4.1.12 Illuminance test shall be carried out every 6 months during defect liability / warranty / contract period (whichever is applicable) to ensure the performance of the installed system conform to the design requirement as per JKR specifications. This test will also confirm the lumen maintenance of the bulb.

12.4.1.12.1 The bulb supplier shall provide calibrated illuminance meter and have the capacity and competency to carry out the illuminance test during the testing of the installed lighting system.

12.4.1.13 The bulb shall comply to the following characteristic:

Characteristic	Description		
Light Source	Lighting Class LED		
Lamp Cap	E26/E27		GU5.3(MR16)
Correlated Colour Temperature, CCT	2700K,3000K, 3500K	4000K/4100K, 4500K	2700K, 3000K
Power Supply	230V +10%, -6%, 50Hz		
Power Consumption	≤9W	≤9W	≤7W
Power Factor	≥ 0.90		
Total Luminous Flux (Lumens)	≥ 450	≥ 550	≥ 200
System Efficacy	≥ 55lm/W	≥ 60lm/W	≥ 50lm/W
Color Rendering Index, CRI	≥ 80		≥ 80
Ambient Temperature	-20˚C to 35˚C		
Rated Lifetime	≥ 40,000 hours, 70% lumen maintenance at Ta=25˚C		
LED Photobiological Safety Class	Exempt group (IEC 62471)		
Heat sink material	Aluminium		
Diffuser / housing type	Frosted		
Total Harmonic Distortion (THD)	≤20%		

Table 12.4.1 Characteristic of LED Bulb

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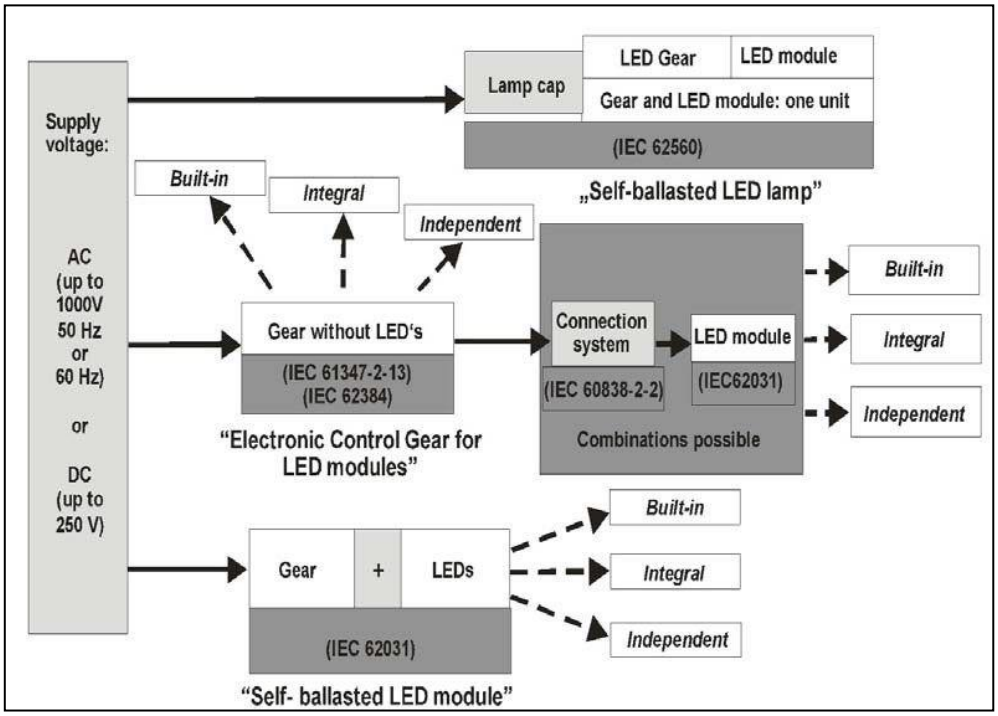

Figure 12.4.1: Overview of System Composed of Self Ballasted LED Lamp (Informative)

12.4.1.14 Conformity with Standards

The bulb shall comply with and be tested to the relevant latest edition of Malaysia Standard or other relevant latest international standard as below:

Item	Criteria	Relevant Standard
Safety & construction	Luminaire & Lamps	**MS IEC 62560** Self-ballasted LED-lamps for general lighting services by voltage > 50V – Safety specifications
		MS IEC 60598-1: Luminaires – Part 1: General requirements and tests

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Item	Criteria	Relevant Standard
		MS IEC 60598-2-1 Luminaires. Part 2: Particular requirements. Section Two: Fixed general purpose luminaires
		MS IEC 60598-2-2 Luminaires Part 2 :Particular requirements - Section 2: Recessed luminaires
	LED driver	**MS IEC 61347-1** Lamp control gear – Part 1: General and safety requirements
		MS IEC 61347-2-13 Lamp control gear- Part 2-13 – Particular requirement for d.c or a.c supplied electronic controlgear for LED modules.
	LED module	**MS IEC 62031** LED modules for general lighting – Safety specifications
	Lamp caps and holder	**MS IEC 60061** International recommendations regarding lamp caps and holders together with gauges for the control of interchangeability
Safety	Lamp holder	**MS IEC 60838-2-2** Miscellaneous lampholders – Part 2-2 – Particular requirements – connectors for LED modules
Safety	LED lamps/modul (eye protection)	**IEC 62471** Photobiological safety of lamps and lamp systems
Performance	LED driver	**MS IEC 62384** DC or AC supplied electronic control gear for LED modules – Performance requirements
Performance	LED Luminaires	**MS 62722-1** Luminaire Performance - Part 1: General Requirements

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Item	Criteria	Relevant Standard
		MS 62722-2-1 Luminaire Performance - Part 2-1: Particular Requirements for LED Luminaires
Performance	LED Lamp	**MS 62612** Self Ballasted LED-Lamps For General Lighting Services- Performance Requirements
Performance	Photometric	**IES LM-79-08** Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products
Performance	LED Light Source (*by LED Manufacturer)	**IES LM-80-08** Approved Method: Measuring Lumen Maintenance of LED Light Sources
Performance	LED Light Source (*by LED Manufacturer)	**IES TM 21-11** Projecting Long Term Lumen Maintenance of LED Light Sources
Safety	EMC	**MS IEC 61547** Equipment For General Lighting Purposes- EMC Immunity Requirements
		IEC 61000-3-2 ELECTROMAGNETIC COMPATIBILITY (EMC) –Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤16 A per phase)
Performance		**CISPR 15 (BS EN 50015)** Limits and Methods of Measurement of Ratio Disturbance Characteristics of Electrical Lighting And Similar Equipment

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12.4.2 LED DOUBLE CAPPED LAMPS (T8 LED TUBES)

12.4.2.1 T8 LED Tubes shall be of the type approved by Suruhanjaya Tenaga (ST).

12.4.2.2 T8 LED Tubes shall comply with the relevant Malaysian Standards or IEC standards and other relevant standards where applicable in terms of safety and performance criteria. It shall be manufactured under “Lighting Class LED” and shall be commercially available.

12.4.2.3 T8 LED Tubes, electronic control gear (LED driver) and accessories shall comply with MS IEC 61347-1, MS IEC 61347-2-13, MS IEC 62031, MS IEC 60838-2-2, MS IEC 60061, MS IEC 62384, MS 62722-1, MS 62722-2-1, IES LM-79-08, IES LM-80-08, IES TM 21-11, IEC 62471, IEC 61547, IEC 61000-3-2, BS EN 55015 or CISPR 15 and shall fit to luminaires that comply to MS IEC 60598-1, MS IEC 60598-2-1 and MS IEC 60598-2-2.

12.4.2.4 The T8 LED Tubes shall be designed and manufactured to suit standard T8 bi-pin fluorescent lamps and capable of providing the service for which is intended. The manufacturers shall provide complete technical installation manual & maintenance manual.

12.4.2.5 The T8 LED Tubes shall be suitable for supply voltage of 230V, +10%, -6% at 50Hz with power factor corrected to at least 0.9 lagging and shall not produce voltage disturbance or fluctuation to the electrical supply system during the mode of operation.

12.4.2.6 The T8 LED Tubes shall operate well within the ratings with due consideration for the local conditions (high humidity up to 95% RH and ambient temperature of 35°C).

12.4.2.7 Interchangeability of consumable components is preferred for maintenance purposes.

12.4.2.8 T8 LED Tubes shall have housing made from Aluminum or Polycarbonate or other materials that sufficiently proven resistance to heat and flame.

12.4.2.9 Material used for the construction of the T8 LED Tubes shall be recyclable.

12.4.2.10 The T8 LED Tubes shall be new, totally enclosed and shall have protection against contact with live or moving parts inside the enclosure.

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12.4.2.11 The electronic control gear (LED Driver) shall comply with MS IEC 61347-1, MS IEC 61347-2-13 & MS IEC 62384 while LED Module shall comply with MS IEC 62031 and shall be of the type approved by Suruhanjaya Tenaga (ST).

The possible combination systems composed of LED Modules and LED Driver are described in Figure 12.4.2 below (Please note that MS IEC 62560: Self Ballasted LED Lamp is not applicable for T8 LED Tubes).

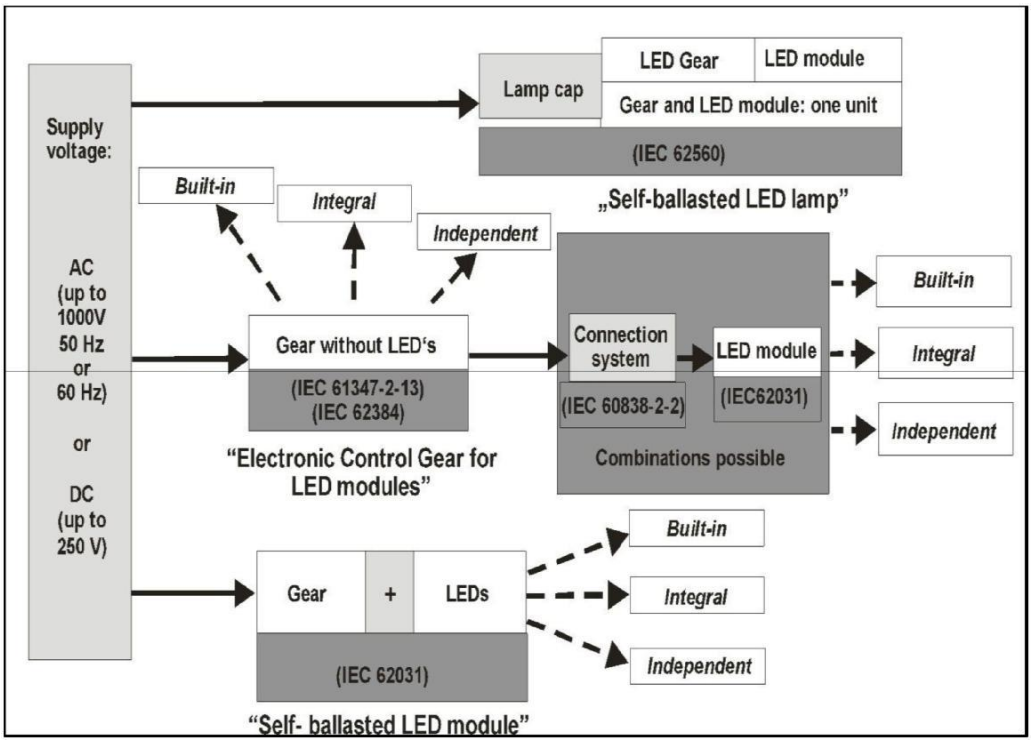

Figure 12.4.2: Overview of System Composed of LED Modules and Control gear (Informative)

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12.4.2.12 LED modules with integrated control gear and equipped with lamp cap (i.e. self- ballasted lamp), intended for retrofit applications (thereby to replace existing lamps with identical lamp caps) shall comply with requirement of IEC 60968.

12.4.2.13 The lamp holders and caps shall comply with MS IEC 60061 and shall be made of polycarbonate material. The T8 LED Tubes shall fit into its intended position with no permanent deformation when inserted into lamp holder and shall be capable of easy and correct positioning by the user. The lamp cap shall be G13 type and total weight of T8 LED Tubes plus lamp cap shall not exceed 500 g as specified in MS IEC 60598-1.

12.4.2.14 The T8 LED Tubes shall be constructed with protection against accidental contact with live parts when the tubes are installed.

12.4.2.15 Harmonics distortion shall be within the limits in accordance with MS IEC 61000-3-2 and total harmonics distortion shall be less than 20%. The T8 LED Tubes shall operate and maintain consistent light output over voltage variation from +10%, -6% of the rated voltage and power factor of not less than 0.9 lagging.

12.4.2.16 The LED luminous flux output of LED light source shall not be depreciated to below 70% of the original output during life hours. The initial luminous flux shall not be less than 90% of the rated luminous flux.

12.4.2.17 The T8 LED Tubes which incorporating multiple numbers of LEDs or LED modules shall continue to operate even though there is failure of a partial number of LEDs or LED modules.

12.4.2.18 The LED / LED module shall not be driven more than the rated drive current.

12.4.2.19 Photometric data for the T8 LED Tubes shall be made available and submitted to S.O.'s Representatives . The required photometric data for the tubes shall be Polar Curve, Utilization Factor, Luminance Distribution Table, Light Output Ratio and Spacing To Mounting Height Ratio.

12.4.2.20 Conformity testing during manufacture of T8 LED Tubes shall be carried out at 100% of production as per MS IEC 62031 with the combination of measurement of input power at rated voltage, current and electrical test shall be as specified in MS IEC 60598-1.

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12.4.2.21 The manufacturer shall provide a minimum 5 years period warranty certificate as stated in the defect liability / warranty / contract period (whichever is applicable) for the complete LED Tubes to guarantee the long life expectancy and maintenance free bulb. Warranty declaration shall be filled and signed by manufacturer. Failure in the functioning and operation of the LED luminaire/tube within the warranty period will result in the replacement of the whole luminaire or required components by the manufacturer at no cost to the government.

12.4.2.22 Illuminance test shall be carried out every six (6) months during defect liability / warranty / contract period (whichever is applicable) to ensure the performance of the installed system conform to the design requirement as per JKR specifications. This test will also confirm the lumen maintenance of the LED Tube.

12.4.2.22.1 The supplier/manufacturer shall provide calibrated illuminance meter and have the capacity and competency to carry out the illuminance test during the testing of the installed lighting system.

12.4.2.23 The T8 LED Tubes shall be bi-pin type and the minimum characteristic shall be as per Table 12.4.2 below:

Specifications	600mm T8	1200mm T8
Total Luminous Flux (lumens)	≥ 840 lm	≥ 1400 lm
Power, W	≤ 11 W	≤ 20 W
Ingress of Protection, IP	Min IP2X	
Power Factor	≥ 0.9	
System Efficacy, lm/W	≥ 70 lm/W	≥ 80 lm/W
Correlated Colour Temperature, CCT	2700K, 3000K, 3500K, 4000/4100K 4500K, 5000K, 6500K	
Colour Rendering Index, CRI	≥ 80	
Diffuser/Lens Type	Frosted	
Beam Angles	≥ 120°	
Total Harmonic Distortion, THD	< 20 %	
Lifespan of T8 LED Tubes, Lx@hrs	≥ L_{70}@30 000	

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Specifications	600mm T8	1200mm T8
Classifications; Integrated, built-in or independent	Integrated / built in	
Lamp cap	G13	
Housing material	Aluminum, Polycarbonate	
Heat sink material	Aluminum	
LED Photo biological class (Group risk of eye safety)	Exempt Risk group (as per IEC 62471)	
Working temperature, T	-20°C to +45°C	
Working humidity	Up to 95% RH	
Dimension: Length (mm) x Diameter (mm)	Typical 600 x 26	Typical 1200 x 26
Weight, g	Typical 280	Typical 280

Table 12.4.2: Characteristics of T8 LED Tubes

12.4.2.24 Conformity with Standards

The T8 LED Tubes shall comply with and be tested to the relevant latest edition of Malaysia Standard or other relevant latest international standard as below:

Item	Criteria	Relevant Standard
Safety & construction	Luminaire	**MS IEC 60598-1** Luminaires – Part 1: General requirements and tests
		MS IEC 60598-2-1 Luminaires. Part 2: Particular requirements Section One: Fixed general purpose luminaires
		MS IEC 60598-2-2 Particular requirements , Part 2- Section 2: Recessed luminaires

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Item	Criteria	Relevant Standard
	LED driver	**MS IEC 61347-1** Lamp control gear – Part 1: General and safety requirements
		MS IEC 61347-2-13 Lamp control gear- Part 2-13 – Particular requirement for d.c or a.c supplied electronic controlgear for LED modules.
	LED module	**MS IEC 62031** LED modules for general lighting – Safety specifications
	Lamp caps and holder	**MS IEC 60061** International recommendations regarding lamp caps and holders together with gauges for the control of interchangeability
Safety	Lamp holder	**MS IEC 60838-2-2** Miscellaneous lampholders – Part 2-2 – Particular requirements – connectors for LED modules
Safety	LED lamps/module (eye protection)	**IEC 62471** Photobiological safety of lamps and lamp systems
Performance	LED driver	**MS IEC 62384** DC or AC supplied electronic control gear for LED modules – Performance requirements
Performance	LED Luminaires	**MS 62722-1** Luminaire Performance - Part 1: General Requirements
		MS 62722-2-1 Luminaire Performance - Part 2-1: Particular Requirements for LED Luminaires

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Item	Criteria	Relevant Standard
Performance	Photometric	**IES LM-79-08** Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products
Performance	LED Light Source (*by LED Manufacturer)	**IES LM-80-08** Approved Method: Measuring Lumen Maintenance of LED Light Sources
Performance	LED Light Source (*by LED Manufacturer)	**IES TM 21-11** Projecting Long Term Lumen Maintenance of LED Light Sources
Safety	EMC	**IEC 61547** Equipment For General Lighting Purposes-EMC Immunity Requirements
		IEC 61000-3-2 ELECTROMAGNETIC COMPATIBILITY (EMC) –Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤16 A per phase)
Performance		**CISPR 15 (BS EN 50015)** Limits and Methods of Measurement of Ratio Disturbance Characteristics of Electrical Lighting And Similar Equipment

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13.0 CEILING FANS

13.1 Ceiling fans offered shall be comply with MS IEC 60335-1, MS 1597 and MS 1220 and of JKR approved brand and model. For 1500mm sweep ceiling fan, minimum air delivery at rated voltage at full speed shall be not less than 210 m^3/min. Safety thermal fuse (130˚C, 2A) shall be incorporated against power surge and overheat.

13.2 All parts of the suspension system of the ceiling fan such as the fan hook, shank assembly, down rod, motor shaft etc. shall be secured by means of high tensile steel shackle bolts; locknuts complete with washers and spring washers and split pins. Split pins shall be positioned as close as possible to the locknuts after the latter have been properly tightened. Instructions as follows, in multi languages, shall be prominently displayed at the midway of the suspension rod: “AMARAN - Ketatkan Semua Nut”. (In Malay & English)

13.3 Ceiling fans shall be provided with a supplementary independent suspension system (safety wire rope) event of failure of the rod suspension system, the fan motor will be safely suspended by this safety wire rope from the fan hook and electricity supply to the ceiling fan shall be disconnected. Disconnection of electricity supply to the ceiling fan shall be accomplished without snapping or damaging the supply cable of the ceiling fan point. It shall also not result in exposing any live terminal within the ceiling fan.

13.4 The material used for the safety wire rope shall be anti-corrosive type. Design and construction of the safety wire rope and disconnection of electricity supply shall be subject to the approval of JKR. These features must be assembled in the manufacturer's factory.

13.5 Standard rod ceiling fans shall be preassembled in the manufacturer’s factory. The down rod shall be minimum 225mm (factory supplied) and more than 225mm of modified (non standard rod) must supplied by the same manufacturer, similar material, complete with safety wire rope, marking and installation instruction.

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13.6 The rubber suspension bush shall properly fit the shank assembly. The upper canopy shall be so secured that it will not slide downward. All ceiling fan shall be provided with suitable earth terminal. The capacitors used shall be of dry self-healing, metalised polypropylene type.

13.7 All ceiling fans shall be provided with matching speed regulator of the ventilated type complete with earth terminal. The regulator knob shall be secured in such a way that it can only be removed by a tool. Fan shall be fitted with well-balanced blades with proper identification to prevent mixing of blades.

13.8 All ceiling fan points shall be completed with speed regulator mounting block and 3 way connector. Where a ceiling fan is installed near a beam, the suspension rod of the ceiling fan shall be of suitable length such that there is a clearance of not less than 75mm between the underside of the beam and the fan blades.

13.9 Capacitors for use with ceiling fan motors shall comply with IEC 60252-1. The rated voltage shall be at least 500VAC with a rated frequency of 50Hz and a maximum permissible operating temperature of 85˚C.

13.10 The windings of the capacitors shall be contained in a casing made from fire retardant material and shall be totally encapsulated with a thermosetting resin.

13.11 The capacitors shall be designed for a minimum life expectancy of 10,000 hours (Class B as defined in IEC 60252-1) when operating continuously at the rated voltage, temperature and frequency.

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14.0 EARTHING

14.1 All system earthing and equipment earthing shall comply with Electricity Regulations 1994 and relevant parts of MS IEC 60364.

14.2 The protective conductor, copper tape and earth electrode shall comply with BS EN 13601.

14.3 All protective conductors shall be of high conductivity copper conductor either stranded or solid, continuous throughout the whole lengths and without joints. In the instance where joints cannot be avoided, then the joints shall be of exothermic welding type. Mechanical clamps may only be used upon approval of the S.O. The joint shall be robust design and protected from mechanical damage and corrosion. Before connecting the protective conductor, the metal works, the conductors and the metal work at the point of contact, including the clamps, shall be thoroughly cleaned of surface corrosion or paint and tinned to ensure that good electrical contact is made.

14.4 Every circuit of a switchboard, distribution board, control board and tap-off units, all lighting points, lighting switches, fan points, fan switches, three pin switched or unswitched socket-outlets, power point etc. shall be provided with circuit protective conductors. All exposed conductive parts and extraneous conductive parts shall be effectively bonded to earth.

14.5 Unless otherwise specified, the minimum cross sectional area of the protective conductors shall be in accordance with the following Tables/Clause in the MS IEC 60364-5-54: -

(a) Circuit protective conductors - Table 54.3 (or BS 7671 Table 54G)

(b) Earthing conductors - Table 54.3 (where buried in the soil, the cross-sectional areas shall be in accordance with Table 54.2 or BS 7671 Table 54A)

(c) Bonding conductors - Clause 544 (or BS 7671 Clause 547)

14.6 Where connections are made at switchgear and such items of electrical equipment the protective conductors shall terminate in a cable lug or other approved means.

14.7 In the case of MICC cables, the copper outer sheath may be utilised as earth protective conductor provided that at the termination of each cable run the copper sheath is effectively bonded to earth.

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14.8 Cable glands shall be installed for termination of armoured cables. It shall be mechanical type complying with BS EN 50262. Each cable gland shall be installed with back nuts (lock nuts) for plain hole fixing.

14.9 Cable gland shall be installed for termination of steel armoured multicore cables and shall comply with BS EN 50262. The cross sectional of a protective conductor connecting a gland earth tag washer to the earth terminal of an enclose shall be selected in accordance with table 54.3 of MS IEC 60364-5-54.

Cross-sectional area of line conductor *S* (mm^2)	**Minimum cross-sectional area of the corresponding protective conductor** (mm^2)	
	If the protective conductor is of the same material as the line conductor	**If the protective conductor is not of the same material as the line conductor**
$S \leq 16$	S	$\frac{k_1}{k_2} \times S$
$16 < S \leq 35$	16	$\frac{k_1}{k_2} \times 16$
$S > 35$	$\frac{S}{2}$	$\frac{k_1}{k_2} \times \frac{S}{2}$

Table 54.3 of MS IEC 60364-5-54 – Minimum cross-sectional area of protective conductors

	Mechanically protected	**Mechanically unprotected**
Protected against corrosion	2.5 mm^2 Cu 10 mm^2 Fe	16 mm^2 Cu 16 mm^2 Fe
Not protected against corrosion	25 mm^2 Cu 50 mm^2 Fe	

Table 54.2 of MS IEC 60364-5-54 (BS 7671 Table 54A) – Minimum cross-sectional areas of earthing conductors buried in the soil

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14.10 The cable gland for aluminium armoured single-core cables shall be made of non-ferrous material.

14.11 In the case of solid earthing, main earthing terminals or bars mounted on porcelain insulators shall be provided external to the switchboard on the wall near to the switchboard as indicated in the drawings. Unless otherwise specified, main earthing bar shall be of tinned copper bar of dimension as in Table 14A with respect to the prospective earth fault current. Main earthing bar shall be of sufficient length to accommodate termination for all protective conductors, earthing conductors and main equipotential bonding conductors of electrical installation, lightning protection system bonding conductor and generator installation bonding conductor. Means shall be provided for disconnecting the earthing conductors to permit measurement of the resistance of the earthing arrangements. The joints shall be disconnectable only by means of a tool, and shall be mechanically strong to ensure electrical continuity. ~~A~~ Permanent label marked with words 'Main Earthing Bar - Safety Electrical Connections - Do Not Remove' shall be installed near to the main earthing bar. All connections to the main earthing bar~~s~~ shall be soundly made and electrically satisfactory by means of bolts and nuts with spring washers and jam nuts.

14.12 Two sets of earthing conductors of copper tape dimension as in Table 14A shall be provided to connect the main earthing bar to two different earth electrodes. The earthing conductors shall be buried in the ground at a depth of not less than 600mm below finished ground level.

14.13 Protective conductor~~s~~ between switchboard and main earthing bar shall be linked by copper tape of same cross sectional area as the main earthing bar.

Prospective Earth fault currents (I) for 1s duration	Main Earthing Bar (Width x Thickness)	Earthing Conductors (No. x Copper tape size)
I ≤ 10 kA	25 mm x 3 mm	2 sets of 1 x 25mm x 3mm
10 kA < I ≤ 25 kA	25 mm x 6 mm	2 sets of 1 x 25mm x 3mm
25 kA < I ≤ 30 kA	30 mm x 6 mm	2 sets of 2 x 25mm x 3mm
30 kA < I ≤ 40 kA	40 mm x 6 mm	2 sets of 2 x 25mm x 3mm
40 kA < I ≤ 50 kA	50 mm x 6 mm	2 sets of 2 x 25mm x 3 mm

Table 14A: Dimensions of Main Earthing Bar and Earthing Conductors

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14.14 Earth electrodes shall be of copper-jacketed steel core rods with 16mm nominal diameter and supplied in 1500mm length and shall have provision for screw coupling with another standard length. The copper jacket of 99.9 % pure 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 non separable. Each earth electrode 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, but less than twice, the driven depth of the earth electrode. Earth electrodes shall not be installed close to a metallic fence. Unless the metallic fence is separately earthed, the fence shall be separated from the electrical earthing system by at least 2000mm. Interconnection between different earth electrodes shall be by means of 25mm x 3mm annealed copper tape.

14.15 In cases where there is insufficient land area, an alternative earthing system shall be proposed for the S.O. approval.

14.16 Where the location of the installation is such that it is not possible in practice to provide the two auxiliary earth electrodes for the test, two test earth electrodes namely potential test probe and current test probe shall be installed. The test earth electrodes shall be one length of 1500mm in depth. The current test probe shall be placed 30m from the first earth electrodes with potential test probe midway between. Test leads of 2.5 sq. mm PVC insulated cable connecting test earth electrodes shall be terminated independently on the porcelain insulators next to the main earthing terminals or bars. The test leads shall be protected by means of non metallic conduit and buried in the ground at a depth of not less than 600mm below finished ground level. Termination shall be identified with permanent labels durably and legibly marked with words ‘Potential Earth Test Probe - Do Not Remove’ and ‘Current Earth Test Probe - Do Not Remove’. Similar labels of not less than 4.75mm high shall be permanently fixed in a visible position at earth electrodes.

14.17 The connection of the earthing conductor and/or the earth electrode 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°C or by exothermic welding.

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14.18 Each earth electrodes shall be provided with heavy duty type inspection chamber with removable cover. The inspection chamber shall be of square or round type and tested in accordance with MS 26: Part 2. The minimum size of square type inspection chamber shall be 300mm (width) x 300mm (length) x 180mm (height) and for round type inspection chamber, the minimum size shall be 300mm (diameter) x 180mm (height). The working load of the inspection chamber shall be minimum 4500kg. Lifting hook shall be provided in the cover. The brand name shall be durably marked on the removable cover.

14.19 Residual current operated circuit breaker (RCCB) shall be provided with minimum cross sectional area 16mm^2 green PVC insulated copper conductor cable as earthing conductors, one set of two (2) length of 1500mm earth electrodes, inspection chambers and removable covers. However, if they are connected to a main earthing system, separate earth electrode need not be provided.

14.20 A permanent label durably marked with words 'Safety Electrical Connection – Do Not Remove', in legible type not less than 4.75mm high, shall be permanently fixed in a visible position at or near: -

14.20.1 The point of connection of every earthing conductor to an earth electrode, and

14.20.2 The point of connection of every bonding conductor to extraneous conductive parts.

14.21 In addition**,** each earthing point shall be identified by permanent label legibly marked with the words 'MSB Earth', 'SSB Earth', 'RCCB Earth' or any other appropriate words permanently fixed to the point of connection of every earthing conductor and earth electrode.

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15.0 LABELLING

15.1 Labels shall be fitted on the outside of all switchgears, fusegears, distribution boards, sub switchboards and main switchboards by means of non-corrodable screws or rivet or any other method approved by the S.O.'s Representative. The labels shall be of laminated plastic with engraved lettering with details such as type of equipment, rating, setting, to/from where it is connected etc.

15.2 The exact wording of the labels shall be agreed with the S.O.'s Representative. Single line mimic schematic circuit diagram shall be provided at the facial of the main switchboards showing the connection of all switchgears with respect to busbars indicating the incoming and outgoing feeders. The diagram shall be single line of width 20mm with yellow perspex strip rivetted on the outside front cover of the switchboard with arrow head indicating the direction of supply incoming to the switchgears.

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16.0 SWITCHROOM

16.1 Approved type of rubber mat shall be provided in front of the switchboards and any other control boards. The rubber mat shall extend to the full length of the switchboards, and shall be of thickness not less than 6mm and width 1000mm. Standard notices displaying the words 'BAHAYA' and 'DILARANG MASUK' and Electric Shock Treatment Chart shall be provided and installed at a place as required in accordance with Electricity Regulations 1994. Signage with words ‘BILIK SUIS UTAMA’, ‘BILIK SUIS’, ‘BILIK KHIDMAT ELEKTRIK’ and ‘DILARANG MEROKOK’ shall be installed for all rooms containing electrical switchboard and equipment to the satisfaction of the S.O.'s Representative.

16.2 All electrical switchrooms shall be provided with one unit 9kg dry powder fire extinguisher for A, B, C class of fire complete with pressure gauge, discharge\ hose with nozzle installed on wall bracket. The extinguisher shall be certified by Jabatan Bomba Dan Penyelamat Malaysia valid to be used for a period of twelve months from the completion date of the Contract.

16.3 All trenches in the switchrooms shall be clear from debris and filled up with clean sand to a level above cable ducts. All cable duct entry into the cable trench shall be sealed tight with cement against water and rodent entry. As-installed layout plans, schematic wiring diagrams and plans showing cable routes and positions of earthing point with reference to easily recognizable buildings and structures shall be suitably framed up in the switchroom. These plans and diagrams shall be in addition to the 4 sets of prints required to be submitted to the S.O.'s Representative, after completion of the project as stated in 20.2.

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17.0 REQUIREMENT FOR ANTI CORROSIVE TYPE INSTALLATIONS

17.0.1 Installation at coastal areas (defined as within 3km from the coast) and other areas deemed necessary, material used shall be of rust proof type and/or anti corrosive type or specially treated. The cost of the material used and treatment applied is deemed to be included in the prices quoted.

17.0.2 Areas within 3km to 5km from the coast, special treatment for salt-spray environment is applicable for external installation only.

17.1 WIRING

17.1.1 Conduit shall preferable be buried in the wall or buried in the concrete ceiling / soffit of slab.

17.1.2 In the false ceiling, conduit used shall be of rigid high impact PVC type grade Heavy Duty Code No. 4421.

17.1.3 Surface conduit wiring if any, must be with the approval of S.O. Steel conduits shall not be used except for emergency circuits. It shall be in rigid high impact PVC conduit grade Heavy Duty Code No. 4421 with its associated system accessories.

17.1.4 Cable trunking and cable tray system shall be of hot dipped galvanized sheet steel. All trunking elbows, offset and combination elbows, adaptors and tees shall be of same thickness as the straight trunking and shall be the type manufactured and supplied by the same trunking manufacturer. Any cut edges shall be painted with galvanized paint. All screws and nuts used shall be made from brass/stainless steel.

17.1.5 All support accessories such as angle iron, brackets, etc. must be of hot dipped galvanized sheet steel.

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17.2 SWITCHBOARDS (MAIN SWITCHBOARD, SUB SWITCHBOARD AND DISTRIBUTION BOARD)

17.2.1 All switchboards shall be installed within enclosed electrical service rooms.

17.2.2 All switchboards shall be of stainless steel material (Grade SS 316).

17.2.3 All screws and nuts shall be of brass/stainless steel.

17.2.4 Special Treatment For Housings Of Electrical Items Used In Salt-Sprayed Environment as per 17.6 shall be applied.

17.3 SWITCHES, SWITCHED SOCKET OUTLETS AND UNSWITCHED SOCKET OUTLETS

17.3.1 For concealed installation, metalclad type back boxes shall be of galvanized sheet steel.

17.3.2 For surface and outdoor installation, switches, switched socket outlets and unswitched socket outlets shall be of sealed or anti corrosive type.

17.4 LUMINAIRES

17.4.1 Fluorescent luminaires installed at external areas (e.g. covered walkways, corridors) and non air-conditioned rooms, shall be of anti corrosive type with a minimum Ingress Protection of IP65.

17.4.2 Other than rust proof luminaires, all other luminaires (whether recessed or surfaced mounting, together with all its related installation accessories i.e. steel wires, suspension rods) shall undergo anti corrosive treatment process as per 17.6.

17.4.2.1 All screws and nuts shall be of brass/stainless steel.

17.4.3 Special Treatment For Housings Of Electrical Items Used In Salt-Sprayed Environment as per 17.6 shall be applied.

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17.5 CEILING FANS AND EXHAUST FANS

17.5.1 All fans shall be of rust proof type.

17.5.2 Anti corrosive treatment for ceiling fan shall be similar to luminaires.

17.5.3 Special Treatment For Housings Of Electrical Items Used In Salt-Sprayed Environment as per 17.6 shall be applied.

17.6 SPECIAL TREATMENT FOR HOUSINGS OF ELECTRICAL ITEMS USED IN SALT-SPRAYED ENVIRONMENT

17.6.1 The treatment shall produce a housing of high resistance to corrosion with a durable finish with smooth reflective white paint. Both the inside and outside of the metal housing shall be finished with double powder coatings of hybrid epoxy polyester compounds. All these housings shall undergo surface preparation and surface pre-treatment before application of first powder coating.

17.6.2 The surface preparation shall consist of firstly chemical cleaning to effectively remove mill scale, rust, contaminants and corrosive compounds; followed by solvent cleaning and degreasing to remove oil or grease. After rinsing, the cleaned surface shall immediately undergo zinc phosphate surface pre-treatment. However, prior to zinc phosphate surface pre-treatment, the surface shall be conditioned with a recommended conditioner. The pre-treated surface shall then be rinsed and dried in the oven before undergoing first powder coating application.

17.6.3 The pre-treated surface shall undergo application of first powder coating and baked in oven. The curing time and temperature shall be as recommended by the powder coating system manufacturer, otherwise at the temperature 204 ºC for 10 minutes. The film thickness of the first powder coating shall be within 50 to 80 microns.

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17.6.4 Next, the part shall be inspected for any defect before applying second powder coating. The second powder coat shall be applied and then the part shall be baked in oven for the recommended time and temperature. The film thickness of the second powder coating shall be within 50 to 80 microns. The finished part shall then be inspected for any defects. The finished colour shall be white.

17.6.5 Each fan blade and housing, luminaire housing and switchboard housing shall be labeled “Double Hybrid Epoxy Polyester Powder Coating”. For identification purposes they shall also carry a model/serial number, brand name and date of manufacture.

17.6.6 The manufacturer shall give warranty/guarantee for the special treatment to the metal parts against corrosion for at 12 months from the date of installation at the site. This warranty/guarantee shall cover full replacement of all defective parts including installation at site at the manufacturer’s expense. The manufacturer shall replace and install the defective parts within 1 week after joint inspection at site.

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18.1 TEST AND CALIBRATION OF MEASURING AND TEST INSTRUMENTS

18.1.1 The test instruments shall be designed, manufactured, tested and shipped in accordance with IEC 61010-1 and IEC 61557-1. All measuring and test instruments used for testing of the electrical installations and, calibration and test for the protection relays shall be regularly tested and calibrated by the manufacturers or accredited calibration laboratories for their functionality and accuracy. The measurement accuracy of reading shall be ± 10 % for analog and digital instruments. Test and Calibration Reports or Certificates for the measuring and test instruments issued by the calibration laboratory shall be valid for 2 years from the date of issuance.

18.1.2 The instruments and their Test and Calibration Reports or Certificates shall be submitted to S.O.'s Representative for verification 2 weeks before testing of the electrical installations being carried out. No test on the electrical installations 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.

18.2 TEST AND TEST CERTIFICATES

18.2.1 After the installation work has been completed and before Certificate of Practical Completion is issued, the electrical installations (covered under this part of the Contract shall be tested as prescribed in Electricity Regulations 1994 and IEC 60364-6 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.

18.2.2 The tests to be carried out where relevant, by the Electrical Contractor shall consist of the following. In the absence of test method in IEC 60364-6, then the testing method adopted shall be as per BS 7671: -

18.2.2.1 Continuity of protective conductors including main and supplementary equipotential bonding conductors.

18.2.2.2 Continuity of ring final circuit conductors.

18.2.2.3 Insulation resistance.

18.2.2.4 Protection by automatic disconnection of the supply:

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18.2.2.4.1 Operation of residual current devices (RCDs)
18.2.2.4.2 Measurement of the resistance of the earth electrode

18.2.2.5 Polarity.

18.2.2.6 Functional and operational tests.

18.2.3 The following additional tests shall be carried out as and when instructed:

18.2.3.1 Protection by Separated Extra Low Voltage (SELV), Protective Extra Low Voltage (PELV), or by electrical separation.
18.2.3.2 Insulation resistance/impedance of floor and wall.
18.2.3.3 Measurement of earth fault loop impedance.
18.2.3.4 Check of phase sequence.
18.2.3.5 Verification of voltage drop.
18.2.3.6 Prospective fault current (BS 7671)

18.2.4 All RCDs shall be checked and tested for their effectiveness in operation within specified sensitivity and tripping time. All protection relays and device shall be checked, tested and calibrated by an Electrical Services Engineer registered with Suruhanjaya Tenaga.

18.2.5 The Electrical Contractor shall arrange with the Electrical Services Engineer to conduct and carry out the stability and functionality test, check and calibration of the protection relays and device. Fee required for the test, check and calibration as described above is deemed to be included in the Contract.

18.2.6 The S.O.'s Representative reserves the right to be present at all tests and the Electrical Contractor shall give at least 1 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 1 week after the completion of the testing.

18.2.7 Supervision and Completion Certificate and Test Certificate including copies of all the test results and drawings as prescribed in Electricity Regulations 1994 shall be submitted to the S.O.'s Representative within two weeks after the completion of the testing. The Certificates shall be properly bound in hard cover and titled.

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19.0 SERVICE AND MAINTENANCE

19.1 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 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.

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

19.2.1 Replacing or making good all luminaires, control gears, capacitors, lamps, switches, sockets-outlets, switched socket outlets, power points, fuses, MCCB, MCB, ACB, RCCB, push buttons, contactors, starters, meters etc.

19.2.2 Replacing all consumable items that do not meet the manufacturer's guaranteed/declared life span or supplying 5% of the total quantity of lamps of each type used in the project.

19.2.3 Replacing and making good all loose and burnt cables and termination, all mechanical support linkage, earth electrode chambers and covers, conduits, trunkings etc.

19.2.4 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.

19.2.5 All other works as deemed necessary by the S.O.'s Representative.

19.3 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 carried out immediately and 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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20.0 SHOP DRAWINGS, AS-INSTALLED DRAWINGS, MANUALS AND TOOLS

20.1 SHOP DRAWINGS

20.1.1 2 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 minimum 2 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 2 weeks from the date of return of the shop drawings. No work including fabrication of the switchboards shall be carried out without the shop drawings being approved by the S.O.'s Representative.

20.1.2 The shop drawings shall include and show the following:

20.1.2.1 The dimensioned general arrangements, layouts and positions of luminaires, wiring accessories such as switches and switched socket outlets, switchgears, distribution boards, switchboards and all others necessary for the complete electrical installations as specified in the Drawings and/or Bill of Quantities;

20.1.2.2 Circuits and switching arrangements including schematic line diagrams of the installation;

20.1.2.3 The dimensioned general arrangements, layouts and routes of final circuits;

20.1.2.4 The dimensioned general arrangements, layouts, routes and positions of all lateral and vertical mains and/or submains;

20.1.2.5 The dimensioned layouts and positions of all holes and cut through in the walls and floors for the lateral and vertical mains and/or submains;

20.1.2.6 The dimensioned general arrangements and layouts of the equipment and the schematic line diagram of the switchboards;

20.1.2.7 Cable routes for all cables laid underground, in ducts and trenches;

20.1.2.8 The dimensioned general arrangements and layout of earthing system including routes for earthing conductors and positions of earth electrodes. The cost of all these shop drawings, whether or not provided in the Bill of Quantities, is deemed to be included in the Contract.

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20.2 AS-BUILT DOCUMENT AND TOOLS

20.2.1 As-Built document shall consist of but not limited to the As-Installed drawings, manuals, certificates, catalogues, inventories and parts lists.

20.2.2 The As-Installed drawing shall comprise of:-

20.2.2.1 Site plan

20.2.2.2 Schematic Wiring Diagram

20.2.2.3 Electrical Layout Plans

20.2.2.4 Control Circuits drawings

20.2.2.5 Layout plans of cable routes

20.2.2.6 Earthing points with reference to easily recognisable buildings and structures.

20.2.3 These drawings shall be labelled at the lower right hand corner with 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), title and following particulars: -

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CAWANGAN KEJURUTERAAN ELEKTRIK
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20.2.4 If the drawings submitted are not according to the actual installation at site and/or not acceptable to 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 to the satisfaction of the S.O.'s Representative.

20.2.5 Manuals and documents for ACB, MCCB and other important electrical switchgears shall be supplied.

20.2.6 The manual shall comprise of:-

20.2.6.1 Installation manual;

20.2.6.2 Operation manual;

20.2.6.3 Service and Maintenance Manual;

20.2.6.4 Parts List;

20.2.6.5 Product Data and catalogue;

20.2.6.6 Product Test Certificates;

20.2.7 Certificates shall comprise of:-

All Testing Certificates (as per section 18.2)

20.2.8 Catalogues, parts lists, inventories, shall be as per project requirements

20.2.9 Each of the As-Built documents shall be bound together with hard cover and submitted in minimum four (4) sets upon issuance of Certificate of Practical Completion of the project.

20.2.10 In addition, one set of the As-Installed drawing shall be submitted in the form of tracing/original document, and two sets in CD ROM.

20.2.11 Special tools required for the operation, service and maintenance of ACB, MCCB and other equipment shall also be provided.

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

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STANDARD	DESCRIPTION
MS 138	SPECIFICATION FOR PVC INSULATION AND SHEATH OF ELECTRIC CABLES
MS 983	SPECIFICATION FOR 'KELUAR' SIGNS (INTERNALLY ILLUMINATED) (SECOND REVISION)
MS 925	SPECIFICATION FOR DIRECT ACTING INDICATING ELECTRICAL MEASURING INSTRUMENTS AND THEIR ACCESSSORIES
MS 619:PART 2-22	PARTICULAR REQUIREMENTS-LUMINAIRES FOR EMERGENCY LIGHTING (FIRST REVISION)
MS 1202	SPECIFICATION FOR CURRENT TRANSFORMERS
MS 1597: PART 2-80	HOUSEHOLD AND SIMILAR ELECTRICAL APPLIANCES - SAFETY - PART 2-80: PARTICULAR REQUIREMENTS FOR FANS
MS 1220	PERFORMANCE AND CONSTRUCTION OF ELECTRIC CIRCULATING FANS AND REGULATORS
MS 26: PART 2	METHODS OF TESTING CONCRETE PART 2 : METHODS OF TESTING HARDENED CONCRETE
MS 274	SPECIFICATION FOR PVC-INSULATED CABLES FOR ELECTRICITY SUPPLY
MS 69	SPECIFICATION FOR CONDUCTORS IN INSULATED CABLES AND CORDS
MS 280	SPECIFICATION FOR COPPER FOR ELECTRICAL PURPOSES, WIRE FOR GENERAL ELECTRICAL PURPOSES FOR INSULATED CABLES AND FLEXIBLE CORDS
MS 138	SPECIFICATION FOR PVC INSULATION AND SHEATH OF ELECTRIC CABLES
MS 275-1	SPECIFICATION FOR STEEL CONDUITS & FITTINGS WITH METRIC THREADS OF ISO FORM FOR ELECTRICAL INSTALLATION PART 1 : STEEL CONDUITS, BENDS & COUPLERS (INTERNATIONALLY ACCEPTABLE SIZES)
MS 1534: PT 1	SPECIFICATION FOR CONDUIT SYSTEMSFOR ELECTRICAL INSTALLATION : PART 1 : GENERAL REQUIREMENTS
MS 1534:PT2 :SEC1	SPECIFICATION FOR CONDUIT SYSTEMS FOR ELECTRICAL INSTALLATION :PART 2 : PARTICULAR REQUIREMENTS :SECTION 1 : RIGID CONDUIT SYSTEMS

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STANDARD	DESCRIPTION
MS 616	SWITCHES FOR HOUSEHOLD AND SIMILAR FIXED-ELECTRICAL INSTALLATION: PART 1 : GENERAL REQUIREMENTS
MS 589	SPECIFICATION FOR 13A PLUGS, SOCKET OUTLETS, ADAPTORS AND CONNECTION UNITS
MS 1577	SPECIFICATION FOR 15 A PLUGS AND SOCKET-OUTLETS FOR DOMESTIC AND SIMILAR PURPOSES
MS 1873	BOXES AND ENCLOSURES FOR ELECTRICAL ACCESSORIES FOR HOUSEHOLD AND SIMILAR FIXED ELECTRICAL INSTALLATION
MS 770	SPECIFICATION FOR CEILING ROSES
MS 769	SPECIFICATION FOR BAYONET LAMPS - CAPS LAMPHOLDERS AND B.C. ADAPTORS
MS 141: PT 2	SPECIFICATION FOR BALLASTS FOR TUBULAR FLUORESCENT LAMPS : PART 2: PERFORMANCE REQUIREMENTS
MS IEC 60038	IEC STANDARD VOLTAGES
MS IEC 60335-1	HOUSEHOLD AND SIMILAR ELECTRICAL APPLIANCES – SAFETY - PART 1: GENERAL REQUIREMENTS
IEC 61035-2-2	SPECIFICATION FOR CONDUIT FITTINGS FOR ELECTRICAL INSTALLATIONS - PART 2: PARTICULAR SPECIFICATIONS - SECTION 2: CONDUIT FITTINGS OF INSULATING MATERIAL
IEC 61035-2-3	SPECIFICATION FOR CONDUIT FITTINGS FOR ELECTRICAL INSTALLATIONS - PART 2: PARTICULAR SPECIFICATIONS - SECTION 3: FITTINGS FOR FLEXIBLE CONDUITS OF METAL, INSULATING OR COMPOSITE MATERIALS AND FOR PLIABLE CONDUITS OF METAL OR COMPOSITE MATERIALS
MS IEC 60598-1	LUMINAIRES PART 1 : GENERAL REQUIREMENTS AND TEST(SECOND REVISION)
MS IEC 60598-2-1	LUMINAIRES PART 2 : PARTICULAR REQUIREMENTS. SECTION ONE: FIXED GENERAL PURPOSE LUMINAIRES
MS IEC 60598-2-2	LUMINAIRES PART 2: PARTICULAR REQUIREMENTS.SECTION TWO: RECESSED LUMINAIRES

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STANDARD	DESCRIPTION
MS IEC 60439-3	LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES – PART 3: PARTICULAR REQUIREMENTS FOR LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES INTENDED TO BE INSTALLED IN PLACES WHERE UNSKILLED PERSONS HAVE ACCESS FOR THEIR USE – DISTRIBUTION BOARDS
MS IEC 60439-5	LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES - PART 5: PARTICULAR REQUIREMENTS FOR ASSEMBLIES INTENDED TO BE INSTALLED OUTDOORS IN PUBLIC PLACES - CABLE DISTRIBUTION CABINETS (CDCS) FOR POWER DISTRIBUTION IN NETWORKS
MS IEC 61084	CABLE TRUNKING AND DUCTING SYSTEMS FOR ELECTRICAL INSTALLATION PART 1: GENERAL REQUIREMENTS
MS IEC 61537	CABLE TRAY SYSTEMS AND CABLE LADDER SYSTEMS FOR CABLE MANAGEMENT
MS IEC 60669-1	SWITCHES FOR HOUSEHOLD AND SIMILAR FIXED ELECTRICAL INSTALLATION PART 1: GENERAL REQUIREMENTS
MS IEC 61643-1	SURGE PROTECTIVE DEVICES CONNECTED TO LOW-VOLTAGE POWER DISTRIBUTION SYSTEMS – PART 1: PERFORMANCE REQUIREMENTS AND TESTING METHODS
MS IEC 60947-1	LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR – PART 1 : GENERAL RULES
MS IEC 60947-2	LOW-VOLTAGE SWITCHGEAR AND CONTOLGEAR - PART 2: CIRCUIT-BREAKERS
MS IEC 60947-3	LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR-PART 3: SWITCHES, DISCONNECTORS,SWITCH-DISCONNECTORS AND FUSE-COMBINATION UNITS
MS IEC 60947-4-1	LOW - VOLTAGE SWITCHGEAR AND CONTROLGEAR - PART 4-1: CONTACTORS AND MOTOR- STARTERS - ELECTROMECHANICAL CONTACTORS AND MOTOR-STARTERS

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STANDARD	DESCRIPTION
MS IEC 60439-1	LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES – PART 1:TYPE-TESTED AND PARTIALLY TYPE-TESTED ASSEMBLIES
MS IEC 61643-12	LOW-VOLTAGE SURGE PROTECTIVE DEVICES – PART 12 : SURGE PROTECTIVE DEVICES CONNECTED TO LOW-VOLTAGE POWER DISTRIBUTION SYSTEMS – SELECTION AND APPLICATION PRINCIPLES
MS IEC 61643-331	COMPONENTS FOR LOW-VOLTAGE SURGE PROTECTIVE DEVICES - PART 331: SPECIFICATION FOR METAL OXIDE VARISTORS (MOV)
MS IEC 61643-311	COMPONENTS FOR LOW-VOLTAGE SURGE PROTECTIVE DEVICES - PART 311: SPECIFICATION FOR GAS DISCHARGE TUBES (GDT)
-	PERATURAN-PERATURAN ELEKTRIK 1994
MS IEC 60364-5-54	ELECTRICAL INSTALLATION OF BUILDINGS – PART 5-54 : SELECTION AND ERECTION OF ELECTRICAL EQUIPMENT: EARTHING ARRANGEMENTS, PROTECTIVE CONDUCTORS AND PROTECTIVE BONDING CONDUCTORS
MS IEC 60364-5-52	ELECTRICAL INSTALLATION OF BUILDINGS -PART 5-52: SELECTION AND ERECTION OF ELECTRICAL EQUIPMENT - WIRING SYSTEMS
MS IEC 60439-2	LOW-VOLTAGE SWITCHGEAR ANDCONTROLGEAR ASSEMBLIES –PART 2 : PARTICULAR REQUIREMENTS FOR BUSBAR TRUNKING SYSTEMS
MS IEC 60928	SPECIFICATION FOR A.C SUPPLIED ELECTRONIC BALLASTS FOR TUBULAR FLUORESCENT LAMPS-GENERAL AND SAFETY REQUIREMENTS.
MS IEC 60929	SPECIFICATION FOR A.C SUPPLIED ELECTRONIC BALLASTS FOR TUBULAR FLUORESCENT LAMPS-PERFORMANCE REQUIREMENTS.
MS IEC 61184	BAYONET LAMPHOLDERS
MS IEC 61000-3-2	ELECTROMAGNETIC COMPATIBILITY (EMC) - PART 3 : LIMITS - SECTION 2 : LIMITS FOR HARMONIC CURRENT EMISIONS (EQUIPMENT INPUT CURRENT LESS THAN AND EQUAL TO 16A PER PHASE)

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STANDARD	DESCRIPTION
MS IEC 61048	AUXILIARIES FOR LAMPS - CAPACITORS FOR USE IN TUBULAR FLUORESCENT AND OTHER DISCHARGE LAMP CIRCUITS - GENERAL AND SAFETY REQUIREMENTS
MS IEC 61049	CAPACITORS FOR USE IN TUBULAR FLUORESCENT AND OTHER DISCHARGE LAMP CIRCUITS PERFORMANCE REQUIREMENTS
MS IEC 60155	GLOW-STARTERS FOR FLUORESCENT LAMPS
MS IEC 60400	LAMPHOLDERS FOR TUBULAR FLUORESCENT LAMPS AND STARTERHOLDERS (FIRST REVISION)
MS IEC 61347-1	LAMP CONTROL GEAR- PART 1:GENERAL AND SAFETY REQUIREMENTS
MS IEC 61347-2-3	LAMP CONTROL GEAR-PART 2-3:PARTICULAR REQUIREMENTS FOR A.C SUPPLIED ELECTRONIC BALLASTA FOR FLUORESCENT LAMPS
MS IEC 61347-2-8	LAMP CONTROLGEAR – PART 2-8: PARTICULAR REQUIREMENTS FOR BALLASATS FOR FLUORESCENT LAMPS
MS IEC 61000	ELECTROMAGNETIC COMPATIBILITY (EMC)
MS IEC 61008-1	RESIDUAL CURRENT OPERATED CIRCUIT-BREAKERS WITHOUT INTEGRAL OVERCURRENT PROTECTION FOR HOUSEHOLD AND SIMILAR USES (RCCBs) - PART 1: GENERAL RULES
MS IEC 61008-2-1	RESIDUAL CURRENT OPERATED CIRCUIT- BREAKERS WITHOUT INTEGRAL OVERCURRENT PROTECTION FOR HOUSEHOLD AND SIMILAR USES (RCCB's) -PART 2-1 : APPLICABILITY OF THE GENERAL RULES TO RCCB's FUNCTIONALLY INDEPENDENT OF LINE VOLTAGE
MS IEC 61009-1	RESIDUAL CURRENT OPERATED CIRCUIT-BREAKERS WITH INTEGRAL OVERCURRENT PROTECTION FOR HOUSEHOLD AND SIMILAR USES (RCBOs) - PART 1: GENERAL RULES
MS IEC 61009-2-1	RESIDUAL CURRENT OPERATED CIRCUIT-BREAKERS WITH INTEGRAL OVERCURRENT PROTECTION FOR HOUSEHOLD AND SIMILAR USES (RCBOS) – PART 2-1: APPLICABILITY OFTHE GENERAL RULES TO RCBOS FUNCTIONALLY INDEPENDENT OF LINE VOLTAGE

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STANDARD	DESCRIPTION
MS IEC 60898-1	ELECTRICAL ACCESSORIES - CIRCUIT-BREAKERS FOR OVERCURRENT PROTECTION FOR HOUSEH OLD AND SIMILAR INSTALLATIONS - PART 1: CIRCUIT-BREAKERS FOR A.C. OPERATION
MS IEC 60898-2	CIRCUIT-BREAKERS FOR OVERCURRENT PROTECTION FOR HOUSEHOLD AND SIMILAR INSTALLATIONS - PART 2:CIRCUIT-BREAKERS FOR A.C. AND D.C. OPERATION
MS IEC 62305	PROTECTION AGAINST LIGHTNING - PART 1: GENERAL PRINCIPLES (FIRST REVISION)
MS IEC 60838	MISCELLANEOUS LAMPHOLDERS
MS IEC 60238	EDISON SCREW LAMPHOLDERS (FIRST REVISION)
IEC 60044-1	INSTRUMENT TRANSFORMERS - PART 1: CURRENT TRANSFORMERS
IEC 60051	DIRECT ACTING INDICATING ANALOGUE ELECTRICAL MEASURING INSTRUMENTS AND THEIR ACCESSORIES
IEC 60359	ELECTRICAL AND ELECTRONIC MEASUREMENT EQUIPMENT - EXPRESSION OF PERFORMANCE
IEC 60255	MEASURING RELAYS AND PROTECTION EQUIPMENT
IEC 60269	LOW-VOLTAGE FUSES - PART 1: GENERAL REQUIREMENTS
IEC 60445	BASIC AND SAFETY PRINCIPLES FOR MAN-MACHINE INTERFACE, MARKING AND IDENTIFICATION - IDENTIFICATION OF EQUIPMENT TERMINALS, CONDUCTOR TERMINATIONS AND CONDUCTORS
IEC 60947-6-1	LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR – PART 6-1: MULTIPLE FUNCTION EQUIPMENT- TRANSFER SWITCHING EQUIPMENT
IEC 60598-2-22	LUMINAIRES – PART 2-22: PARTICULAR REQUIREMENTS – LUMINAIRES FOR EMERGENCY LIGHTING
MS IEC 60529	DEGREES OF PROTECTION PROVIDED BY ENCLOSURES (IP CODE)

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STANDARD	DESCRIPTION
IEC 60502	POWER CABLES WITH EXTRUDED INSULATION AND THEIR ACCESSORIES FOR RATED VOLTAGES FROM 1 KV (UM = 1,2 KV) UP TO 30 KV (UM = 36 KV)
IEC 60702	MINERAL INSULATED CABLES AND THEIR TERMINATIONS WITH A RATED VOLTAGE NOT EXCEEDING 750 V
IEC 60331	TESTS FOR ELECTRIC CABLES UNDER FIRE CONDITIONS - CIRCUIT INTEGRITY
IEC 60332-1	TESTS ON ELECTRIC AND OPTICAL FIBRE CABLES UNDER FIRE CONDITIONS.
IEC 60332-3	TESTS ON ELECTRIC AND OPTICAL FIBRE CABLES UNDER FIRE CONDITIONS
IEC 61034	MEASUREMENT OF SMOKE DENSITY OF CABLES BURNING UNDER DEFINED CONDITIONS
IEC 60423	CONDUIT SYSTEMS FOR CABLE MANAGEMENT - OUTSIDE DIAMETERS OF CONDUITS FOR ELECTRICAL INSTALLATION (L-S1)S AND THREADS FOR CONDUITS AND FITTINGS
IEC 61386-1	CONDUIT SYSTEMS FOR CABLE MANAGEMENT - PART 1: GENERAL REQUIREMENTS
IEC 61386-21	CONDUIT SYSTEMS FOR CABLE MANAGEMENT - PART 21: PARTICULAR REQUIREMENTS - RIGID CONDUIT SYSTEMS
IEC 60614-1	CONDUIT FOR ELECTRICAL INSTALLATION SPECIFICATION PART 1
IEC 60614-2-2	CONDUIT FOR ELECTRICAL INSTALLATION. PARTICULAR SPECIFICATIONS. SPECIFICATIONS FOR RIGID PLAIN CONDUITS OF INSULATING MATERIAL
IEC 60670-1	BOXES AND ENCLOSURES FOR ELECTRICAL ACCESSORIES FOR HOUSEHOLD AND SIMILAR FIXED ELECTRICAL INSTALLATION (L-S1)S - PART 1: GENERAL REQUIREMENTS
IEC 60901	SINGLE-CAPPED FLUORESCENT LAMPS - PERFORMANCE SPECIFICATIONS
IEC 61199	SINGLE-CAPPED FLUORESCENT LAMPS - SAFETY SPECIFICATIONS

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STANDARD	DESCRIPTION
IEC 60968	SELF-BALLASTED LAMPS FOR GENERAL LIGHTING SERVICES - SAFETY REQUIREMENTS
IEC 60969	SELF-BALLASTED LAMPS FOR GENERAL LIGHTING SERVICES - PERFORMANCE REQUIREMENTS
IEC 60252-1	AC MOTOR CAPACITORS - PART 1: GENERAL - PERFORMANCE, TESTING AND RATING - SAFETY REQUIREMENTS - GUIDANCE FOR INSTALLATION AND OPERATION
IEC 61010-1	SAFETY REQUIREMENTS FOR ELECTRICAL EQUIPMENT FOR MEASUREMENT, CONTROL, AND LABORATORY USE - PART 1: GENERAL REQUIREMENTS
IEC 61557-1	ELECTRICAL SAFETY IN LOW VOLTAGE DISTRIBUTION SYSTEMS UP TO 1 000 V A.C. AND 1 500 V D.C. - EQUIPMENT FOR TESTING, MEASURING OR MONITORING OF PROTECTIVE MEASURES - PART 1: GENERAL REQUIREMENTS
IEC 60364-6	LOW-VOLTAGE ELECTRICAL INSTALLATION - PART 6: VERIFICATION
MS IEC 60081	DOUBLE-CAPPED FLUORESCENT LAMPS - PERFORMANCE SPECIFICATIONS (IEC 60081:2003, IDT)
MS IEC 61195	DOUBLE - CAPPED FLUORESCENT LAMPS - SAFETY SPECIFICATIONS (IEC 61195 : 1999, IDT)
IEC 60754-2	TEST ON GASES EVOLVED DURING COMBUSTION OF ELECTRIC CABLES - PART 2: DETERMINATION OF DEGREE OF ACIDITY OF GASES EVOLVED DURING THE COMBUSTION OF MATERIALS TAKEN FROM ELECTRIC CABLES BY MEASURING PH AND CONDUCTIVITY
IEC 61035-1	SPECIFICATION FOR CONDUIT FITTINGS FOR ELECTRICAL INSTALLATION PART 1: GENERAL REQUIREMENTS.
IEC 61035-2-1	SPECIFICATION FOR CONDUIT FITTINGS FOR ELECTRICAL INSTALLATION PART 2: PARTICULAR SPECIFICATIONS - SECTION 1: METAL CONDUIT FITTINGS.
IEEE Std C62.41.2	IEEE RECOMMENDED PRACTICE ON CHARACTERIZATION OF SURGES IN LOW-VOLTAGE (1000 V AND LESS) AC POWER CIRCUITS

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STANDARD	DESCRIPTION
BS 5467	ELECTRIC CABLES. THERMOSETTING INSULATED, ARMOURED CABLES FOR VOLTAGES OF 600/1000 V AND 1900/3300 V
BS 6346	ELECTRIC CABLES. PVC INSULATED, ARMOURED CABLES FOR VOLTAGES OF 600/1000 V AND 1900/3300 V
BS 6387	SPECIFICATION FOR PERFORMANCE REQUIREMENTS FOR CABLES REQUIRED TO MAINTAIN CIRCUIT INTEGRITY UNDER FIRE CONDITIONS
BS EN 50086-1	SPECIFICATION FOR CONDUIT SYSTEMS FOR CABLE MANAGEMENT. GENERAL REQUIREMENTS
BS 1710	SPECIFICATION FOR IDENTIFICATION OF PIPELINES AND SERVICES
BS 4800	SCHEDULE OF PAINT COLOURS FOR BUILDING PURPOSES
BS 1322	SPECIFICATION FOR AMINOPLASTIC MOULDING MATERIALS
BS EN 13601	COPPER AND COPPER ALLOYS. COPPER ROD, BAR AND WIRE FOR GENERAL ELECTRICAL PURPOSES
BS 7671	REQUIREMENTS FOR ELECTRICAL INSTALLATION
BS EN 55015	LIMITS AND METHODS OF MEASUREMENT OF RADIO DISTURBANCE CHARACTERISTICS OF ELECTRICAL LIGHTING AND SIMILAR EQUIPMENT
BS EN 50262	CABLE GLANDS FOR ELECTRICAL INSTALLATION
IEC 60614-2-5	SPECIFICATIONS FOR CONDUITS FOR ELECTRICAL INSTALLATIONS - PART 2: PARTICULAR SPECIFICATIONS FOR CONDUITS - SECTION 5: FLEXIBLE CONDUITS
MS 1873 PART 24	BOXES AND ENCLOSURES FOR ELECTRICAL ACCESSORIES FOR HOUSEHOLD AND SIMILAR FIXED ELECTRICAL INSTALLATIONS - PART 24: PARTICULAR REQUIREMENTS FOR ENCLOSURES FOR HOUSING PROTECTIVE DEVICES AND SIMILAR POWER CONSUMING DEVICES (IEC 60670-24:2005, IDT)
IEC 60670-24	BOXES AND ENCLOSURES FOR ELECTRICAL ACCESSORIES FOR HOUSEHOLD AND SIMILAR FIXED ELECTRICAL INSTALLATIONS - PART 24: PARTICULAR REQUIREMENTS FOR ENCLOSURES FOR HOUSING PROTECTIVE DEVICES AND SIMILAR POWER CONSUMING DEVICES (IEC 60670-24:2005, IDT)

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STANDARD	DESCRIPTION
MS 2112-3	ELECTRIC CABLE AND WIRE - POLYVINYL CHLORIDE (PVC) INSULATED CABLES OF RATED VOLTAGES UP TO AND INCLUDING 450/750 V - PART 3: NON-SHEATHED CABLES FOR FIXED WIRING
MS 2112-4	ELECTRIC CABLE AND WIRE - POLYVINYL CHLORIDE (PVC) INSULATED CABLES OF RATED VOLTAGES UP TO AND INCLUDING 450/750 V - PART 4: SHEATHED CABLES FOR FIXED WIRING
IEC 60688	ELECTRICAL MEASURING TRANSDUCERS FOR CONVERTING A.C. AND D.C. ELECTRICAL QUANTITIES TO ANALOGUE OR DIGITAL SIGNALS
IEC 62471	PHOTOBIOLOGICAL SAFETY OF LAMPS AND LAMP SYSTEMS
IEC 61547	EQUIPMENT FOR GENERAL LIGHTING PURPOSES – EMC IMMUNITY REQUIREMENT
IEC 61347-2-13	LAMP CONTROLGEAR – PART 2-13: PARTICULAR REQUIREMENT FOR D.C. OR A.C. SUPPLIED ELECTRONIC CONTROLGEAR FOR LED MODULES
IEC 62384	DC OR AC SUPPLIED FOR CONTROL GEAR FOR LED MODULES – PERFORMANCE REQUIREMENTS
IEC 62031	LED MODULES FOR GENERAL LIGHTING – SAFETY SPECIFICATIONS
IEC 60838-2-2	MISCELLANEOUS LAMPHOLDER PART 2-2: PARTICULAR REQUIREMENTS – CONNECTORS FOR LED MODULES
IES LM-79-08	APPROVED METHOD: ELECTRICAL AND PHOTOMETRIC. MEASUREMENTS OF SOLID STATE LIGHTING PRODUCTS
IES LM-80-08	APPROVED METHOD: MEASURING LUMEN MAINTENANCE OF LED LIGHT SOURCES

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