LAND TRANSPORT AUTHORITY

TRAFFIC & STREET LIGHTING

GUIDELINES TO THE SUBMISSION OF DESIGN DRAWINGS FOR PUBLIC STREET LIGHTING, CYCLING PATH LIGHTING, FOOTPATH LIGHTING AND ZEBRA CROSSING FLASHING BEACON LIGHTING SYSTEM

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1.0 GENERAL

The Technical Specification in this document sets out the requirements for the design, supply, install, test and commission of modification works, Tech Refurbishment works and new works for Street Lighting and Commuter Facilities Equipment. It is to be noted that the existing Street Lighting and Commuter Facilities Equipment which were constructed over time do not conform to all aspects required under this Technical Specifications document and the Contractor shall have no cause in making any assumption that they fully comply with these Technical Specifications.

1.1 Lighting Design Criteria

1.1.1 General

(a) Illuminance Uniformity - the uniformity of the light distribution on the road shall be at least 0.3 for all categories of road. The uniformity is defined as the ratio of minimum illuminance to the designed average illuminance;

(b) The lux level calculation / simulation based on lighting supplier's lighting data shall be submitted to LTA for acceptance;

(c) All physical lux measurements between lighting poles shall be taken at minimum of nine (9) reference points;

(d) For Street Lighting, the load shall be evenly distributed among the three (3) phases in a single outgoing circuit; and

(e) For Commuter Facilities, the load shall be alternated using two (2) single-phase outgoing circuitries.

1.1.2 Design of Street Lighting

1.1.2.1 The design of street lighting for public roads shall comply with but not limited to the latest edition of BS 5489, BS EN 13201, CIE (International Commission on Illumination) and all applicable Codes, Regulations, Standards, and relevant Authorities.

1.1.2.2 For the purpose of design, road surface shall be taken as Class R3 road (Asphalt CIE R3).

1.1.2.3 The Contractor shall carry out detailed design for the replacement of the existing lanterns to LED luminaires. The detailed design shall be submitted for LTA approval.

1.1.2.4 Detailed design comprises the following and shall comply to Clause 1.1.3:

(a) Conduct site survey (e.g. pole-to-pole distance, produce AutoCAD drawing, etc.) on listed road;

(b) The proposed lighting design shall take into consideration of the existing known underground services within vicinity to avoid conflicts;

(c) Identify the site constraint and problem areas;

(d) Selection of the type of LED luminaires to achieve the design illumination level or propose the most optimal design base on existing road condition (subjected to LTA approval) for the type of roads without the need to adjust the pole-to-pole spacing, change the pole height and arm length; and

(e) Prepare the illumination diagram showing the lux level of the lighting scheme and existing lighting pole layout arrangement.

1.1.3 Street Lighting Level

(a) Illuminance Level - as a guide, the designed lighting levels for the different categories of road for new Street Lighting are as follows:

Type of Roads	Minimum Average Illuminance (at floor level)
Expressway and Major Road	20 lux
Expressway and Major Road conflict area	1.5x (e.g. 30 lux)
Minor and Residential Road	10 lux
Minor and Residential Road conflict area	1.5x (e.g. 15 lux)

(b) The lighting design proposal shall be based on latest edition of BS 5489 (British Standard), BS EN 13201 Part 2, 3 & 4 and CIE 115 (Technical Report of Commission International de L'Eclairage); and

(c) The average illuminance shall be at least 1.5 times the illuminance of the carriageway for conflict areas, like junctions, T-junctions, intersections, cul-de-sac, etc.

1.1.4 Sitting of Street Lighting Pole

1.1.4.1 Sitting of lighting pole adjacent to bridges shall be at least 12 metres away so that the light from the luminaire is not obstructed and does not cause problems of nuisance or glare or danger to users on top of the bridge.

1.1.4.2 Sitting of lighting pole adjacent to gantry shall be at least 10 - 15 metres away so that the light from the luminaire is sufficient to brighten up the surrounding gantry area without casting shadow on the road.

1.1.4.3 The recommended minimum clearance (set-back) from the edge of carriageway to the face of lighting poles shall be as follow:

Type of Roads	Minimum Clearance (from the edge of carriageway)
Expressway	2,000mm and / or 1,000mm away from the VIG
Road	1,000mm

1.1.4.4 Whenever practical and appropriate, lighting pole shall not be installed at the gore area (neutral area).

1.1.4.5 Where normal standard cannot be adopted due to site constraints like abutting properties, nature of the ground topography, it will be dealt with on case-by-case basis not compromising safety.

1.1.4.7 The Contractor shall take reference from the latest SDRE when planting street lighting poles.

1.1.5 Street Lighting Pole Arrangement

1.1.5.1 The following arrangements of lighting poles shall be considered.

(a) Twin central: used on dual carriageways and motorways; provides clear visual guidance for the through route at T-junctions;

(b) Opposite: used on wide roads or dual carriageways where twin central is not suitable due to narrow central reserve width, ground conditions or maintenance access constraints;

(c) Staggered: generally used on traffic routes, residential and subsidiary roads;

(d) Single-sided: used on narrow roads, widely separated carriageways, curved link roads and slip roads; and

(e) Combined twin central and opposite: used for wide carriageway layouts and merge and divide areas where one type of lighting alone is inadequate.

1.1.6 Street Lightings under Flyover

1.1.6.1 For sections of roads which have wide spans of flyover traversing across it, where the height clearance is permissible, the road shall be lighted using normal lighting pole. Where the height is constrained by the flyover, such that it is not possible to install lighting poles underneath the flyover, the affected road section shall be lighted by road LED luminaries from the soffit of the flyover. The LED luminaire used shall be in accordance with the Luminaire Specification under clause 2.1.

1.1.6.2 "F" shape bracket arm shall be the preferred bracket to use. A sample or sketch (N.T.S.) shall be submitted to LTA for his acceptance prior to any site installation.

1.1.6.3 Alternatively, "L" shape bracket arm can be used instead of "F" shape bracket arm due to site constraint. Subjected to LTA approval.

1.1.7 Design of Cycling Path Lighting

(a) The design of lighting for cycling path shall comply but not limit to the latest edition of CIE 136 (Technical Report of Commission International de L'Eclairage), Walking & Cycling Design Guide and all applicable Codes, Regulations, Standards and relevant Authorities;

(b) For the purpose of design, cycling path surface shall be taken as Class R3 road (Asphalt CIE R3);

(c) Illuminance Level - as a guide, the designed lighting levels for the cycling path are as follows:

Type of Cycling path	Minimum Average Illuminance (at floor level)	Minimum Lux (at floor level)	Uniformity
+Non-Conflict areas	5 lux	2 lux	0.25
#Conflict areas	10 lux	3 lux	0.25
Bicycle parking bay / area	30 lux	10 lux	0.3
*Alongside with public streetlights (share path)	5 lux	N/A	N/A
Adjacent to Covered linkway	The covered linkway lights shall be designed to illuminate both the linkway and cycling path in accordance to Walk and Cycle Design Guide		

+ Lighting shall be provided for sidetable more than 500mm (from kerb) with tree planting scheme or unable to meet the minimum average illuminance of 5 lux from existing streetlights.
# Conflict areas refer to carpark entrance, sharp bend, T-junction, etc..
* Subject to existing site condition. Standalone lightings shall be installed if the existing illuminance is not achievable.

(d) The proposed LED luminaire system power shall take reference to Annex C (Table H).

1.1.8 Sitting of Cycling Path Lighting Pole

1.1.8.1 The lighting pole shall be planted single-sided abutting the edge of the cycling path unless otherwise instructed by LTA.

1.1.8.2 The Contractor shall take reference from the latest SDRE and / or Walking & Cycling Design Guide when planting the lighting pole.

1.1.9 Design of Footpath Lighting

(a) The design of lighting pole for footpath shall comply with but not limit to the latest edition of CIE 136 (Technical Report of Commission International de L'Eclairage) and all applicable Codes, Regulations, Standards and relevant Authorities;

(b) For the purpose of design, footpath surface shall be taken as Class C2 road;

(c) Illuminance Level - as a guide, the designed lighting levels for the footpath are as follows:

Type of Footpath	Minimum Average Illuminance (at floor level)	Uniformity
Alongside with public streetlights (without dedicated footpath lightings)	5 lux	N/A
Footpath (with dedicated footpath lightings)	10 lux	0.25

(d) The proposed LED luminaire system power shall take reference from Cycling path lighting system.

1.1.10 Sitting of Footpath Lighting Pole

1.1.10.1 The lighting pole shall be planted single-sided abutting the edge of the footpath unless otherwise instructed by LTA.

1.1.10.2 The Contractor shall take reference from the latest SDRE and / or Walking & Cycling Design Guide when planting footpath lighting pole.

1.1.11 Design of Commuter Facilities Lighting Lux Requirement

Description		Average Lighting level measured at ground level (lux)	Uniformity ratio	Maximum allowable light loading (design) (W/Sqm)	Colour Rendering Index (Ra)	Colour Temperature (K)
Covered Pedestrian Overhead Bridge	Deck / ramp	10	0.25	2.5	80 - 89	3,000
	Lift lobby	50	0.25	2.5	80 - 89	3,000
Staircase		30	0.25	2.5	80 - 89	3,000
Uncovered Pedestrian Overhead Bridge		30	0.25	2.5	80 - 89	3,000
High Covered Linkway		30	0.4	2.5	80 - 89	3,000
Low Covered Linkway		10	0.25	2.5	80 - 89	3,000
Bus / Taxi shelter and Passenger pickup shelter		30	0.3	2.5	80 - 89	3,000
Bicycle Parking Areas		30 lux with min. 10 lux to meet security requirement	-	1.8	80 - 89	3,000
Pedestrian Underpass	Day / Night	100	0.25	2.5	80 - 89	4,000

1.1.11.1 The design criteria of lighting for Commuter Facilities shall comply with but not limited to the LTA's latest edition of The Transport Infrastructure Design Criteria & Specifications (IDC) Guidelines and all applicable Codes, Regulations, Standards and relevant Authorities.

2.0 STREET LIGHTING

2.1 LED Luminaire

2.1.1 General

2.1.1.1 The Contractor shall submit the design of street lighting including lighting simulations and calculations for the proposed LED luminaires based on actual site installation and mountings details to LTA for acceptance prior to procurement and site installation.

2.1.2 Standards

The luminaires shall be in accordance with the applicable requirements of standard specifications listed as follows:

(a) IEC 60598-1: Luminaires - Part 1
General requirements and tests

(b) IEC 60598-2-3: Particular requirements
Luminaires for road & street lighting

(c)	SS IEC 62722-2-1:	Luminaire performance - Particular requirements for LED luminaires
(d)	SS IEC 62722-2-2:	Luminaire performance Part 2 - Particular Requirement for LED Luminaires
(e)	IEC 60068-2-6:	0.5G Vibration (sinusoidal) Test
(f)	ANSI C136-31:	3G Vibration Test
(g)	ASTM B117: / ISO9227	Neutral Salt Spray Test
(h)	SS IEC 62717:	LED modules for general lighting Performance requirements
(i)	IEC 62031:	LED modules for general lighting - Safety specifications
(j)	IEC 62471:	Photobiological safety of lamps and lamp systems
(k)	IEC 62778:	Application of IEC 62471 for the assessment of blue light hazard to light sources and luminaires
(l)	IEC 61347-1:	General and safety requirements for the driver
(m)	IEC 61347-2-11:	Particular requirements for miscellaneous electronic circuits used with luminaires
(n)	IEC 61347-2-13:	Particular requirements for DC or AC supplied electronic control gear for LED modules
(o)	EN IEC 55015 /: CISPR 15	Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment
(p)	IEC 61000-3-2:	Limits for harmonic current emissions (equipment input current ≤ 16A per phase)
(q)	IEC 61000-3-3:	Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤16A per phase and not subject to conditional connection

(r)	IEC 61547:	Equipment for general lighting purposes - EMC immunity requirements
(s)	IEC 62384:	DC or AC supplied electronic control gear for LED modules - Performance requirements
(t)	IES LM-79-08:	Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products
(u)	IES LM-80-08:	Approved Method: Measuring Lumen Maintenance of LED Light Sources
(v)	ISO/IEC 17025:	General requirements for the competence of testing and calibration laboratories

2.1.3 Power Factor and the Total Harmonic Distortion

When the luminaire is operating on a supply voltage of 230 Volts ±6%, at a frequency of 50 hertz ±1%. The circuit power factor shall be 0.90 or better and the Total Harmonic Distortion (THD) ≤ 15% at maximum load.

2.1.4 Maintenance Factor (MF)

Luminaires maintenance factors vary according to the intervals between cleaning, the amount of atmospheric pollution and the quality of the sealing of the LED housing of the luminaires. Their values may be established by field measurements. Luminous flux maintenance factors vary according to LED type and power. Values are usually available from LED chip manufacturers. However, a 0.9 maintenance factor shall be adopted for the purposes of producing the lighting simulation design.

2.1.5 Operating Voltage

The luminaires shall be suitable for use on a supply voltage of 230 Volts ±6%, at 50 hertz ±1%.

2.1.6 Marking

The provision of IEC 60598-2-3 shall apply.

2.1.7 Construction

2.1.7.1 The luminaires shall be designed and constructed so that it is capable of providing the service for which it is intended. Sound engineering principles shall be adopted throughout and the luminaires shall be designed to enable ease of maintenance and replacement of associated components, without the use of special tools on site.

2.1.7.2 The luminaire shall be designed with proper venting and drainage to prevent moisture and condensation from developing without compromising the specified IP rating. The construction of the internal housing and placement of the components within the LED luminaire shall not cause any form of water retention, which may cause the LED luminaire to fail or deteriorate prematurely.

2.1.7.3 The luminaire is by way of “top opening” of the luminaire’s canopy, this ensures an ergonomically sound posture for the service personnel. During opening, the canopy (gear compartment cover) swings upwards / backwards and a stainless steel mechanism falls into position to keep the canopy open. Samples shall be submitted to LTA for acceptance prior to procurement and site installation.

2.1.7.4 The luminaires shall be constructed from corrosion resistant materials such that no undue deterioration occurs in its safety, performance or appearance when operating under local climatic conditions. It shall be robustly constructed to withstand vibration in normal use.

2.1.7.5 The luminaires and its driver shall be designed with adequate protection features to withstand the surges of lightning strikes and the frequent switching operation of the power supplies. The standalone Surge Protection Device (SPD) shall have a protection rating with a minimum of 15kA and End-of-Life Indicator.

2.1.7.6 The thickness of the luminaires body shall be at least 3mm and the maximum weight of the luminaire shall not exceed 20kg.

2.1.7.7 The luminaires shall have indication / label on the external housing to differentiate scenarios where different optics / lens is being used with the same system power. The indication / label must be clearly and indelibly marked and visible at ground level. The Contractor shall submit the proposed indication / label to LTA for acceptance prior to procurement and site installation.

2.1.7.8 A QR code Model 2 for each key component of the LED luminaire shall be attached to the internal compartment in the following sequence and comply with ISO/IEC 18004:2006:

(a) LED luminaire - brand, model number, wattage, serial number and manufacture details in ww/yy format;

(b) LED module - brand, model number, CCT value, serial number and manufacture details in ww/yy format;

(c) Driver - brand, model number, dimming method (e.g.: DALI), serial number and manufacture details in ww/yy format; and

(d) Surge Protection Device units (before driver(primary) and after driver(secondary)) - brand, model number, rating, serial number and manufacture details in ww/yy format.

2.1.7.9 The housing of the luminaires shall be made of non-corrosive high pressure die cast aluminium to ensure the strength and safety of the luminaires on the pole.

2.1.7.10 Corrosion resistance painting and UV-stabilised powder coating or equivalent shall be ensured by using aluminium for housing of the luminaires with less than 1% of copper. All die casting parts shall not have sharp edges for safety of installers and to prevent defects of the painting.

2.1.7.11 Any painting used in the luminaires shall be without Chrome 6 substance for environmental purposes.

2.1.7.12 The proposed RAL & AKZO painting shall be submitted to LTA for acceptance.

2.1.7.13 Mechanical resistance level of the housing shall be at least **IK 08** and Degrees of Protection shall be **IP 66** to prevent any risk to get water or dust inside the luminaires. The **IP 66** level shall be reached without using glue to make the luminaires fully recyclable.

2.1.7.14 Hinges and catches of the luminaires cover shall be robust and simple to operate and shall not be liable to accidental detachment during installation or maintenance. It shall be made of stainless steel.

2.1.7.15 The luminaires cover or other component giving access to the interior of the luminaires shall, in the closed position, be firmly attached to the fixed portion of the luminaires. In the open position, it shall be attached in such a way that there is no likelihood of it becoming accidentally detached or damaging any part of the luminaires, the bracket or the column.

2.1.7.16 The bowl / flat glass shall be made of tempered glass or more superior material and shall form part of the lighting cover. Glass Fragmentation Test shall be conducted and result to be reflected in IEC 60598-2-3 test report.

2.1.7.17 The Contractor shall replace the glass bowl to flat glass or replace with a frosted glass or equivalent on the same luminaires when the need arises due to glare issue. This shall be done easily at site without the need of sealing tools and shall deem to be included in the Contract.

2.1.7.18 Alternatively, an anti-glare shield at the front and / or back of the luminaires when the need arises due to glare issue. This shall be done easily at site without the need of special tools and affecting the IP rating or integrity of the luminaires. The anti-glare shield sample shall be submitted to LTA for acceptance.

2.1.8 Driver

2.1.8.1 Each luminaire shall be provided with its own and replaceable driver. The drivers shall be housed within the luminaire. For LED luminaires with LED wattage less than or equal to 130W, the maximum number of LED driver shall be limited to one (1) number per luminaire. For LED luminaire with LED wattage more than 130W, the maximum number of LED drivers shall be limited to two (2) numbers per luminaire.

2.1.8.2 Driver efficiency shall be greater than 90% at maximum load. The driver efficiency test shall be carried out based on the relevant international standards by accredited laboratories certified under ISO/IEC 17025.

2.1.8.3 Driver shall be of minimum Class II, metal encased and RoHS compliance.

2.1.8.4 Driver shall have a Power Factor (PF) ≥ 0.90 and Total Harmonic Distortion (THD) ≤ 15% at maximum load.

2.1.8.5 Driver shall be rated for at least 100,000 hours lifetime at maximum marked case temperature and an ambient temperature of 70^{o}C or higher.

2.1.8.6 The operating temperature shall be up to 85^{o}C.

2.1.8.7 Driver shall be designed with adequate surge protection features.

2.1.8.8 The driver shall support a minimum of DALI 2.0 and the interface shall be compliant to IEC 62386 or equivalent.

2.1.9 LED Luminaire

2.1.9.1 The LED luminaires shall be of proven track records and type-tested to the requirements as specified. All tests shall be carried out by accredited bodies, laboratories or facilities certified under ISO/IEC 17025. The Contractor shall submit all relevant type test reports, certificates and track records for approval.

2.1.9.2 The rated LED life L80/B20 shall be minimum 100,000 hours or higher at LED operating temperature T_a ≥ 35^{o}C and and RH ≥ 90%.

2.1.9.3 The luminaire colour temperature and system power shall take reference to Annex C (Table H).

(a) The colour rendering index shall be greater than 70; and

(b) The luminous efficacy shall be at least 140lm/W.

2.1.9.4 The following data shall be provided as per IES LM-79: initial electrical & photometric values.

(a) power (W);

(b) luminous flux (lm);

(c) luminous efficacy (lm/W);

(d) Correlated Colour Temperature (CCT);

(e) Colour Rendering Index (CRI);

(f) S/P ratio; and

(g) Total harmonics distortion (THD).

2.1.9.5 Lumen intensity distribution shall be available according to the following standard: BS EN 13032-1 and BS EN 13032-2.

2.1.9.6 The LED luminaire shall be designed with functions / features to prevent the internal components from exposure to over temperature.

2.1.10 Control Socket

2.1.10.1 The luminaire shall be equipped with a 7 pins control socket using ANSI C136.41-2013.

2.1.10.2 The driver shall be pre-wired to the 7 pins control socket using ANSIC136.41-2013.

2.1.10.3 The control socket shall protrude at least 20mm above the luminaire housing.

2.1.10.4 The luminaire shall be of **IP 66** type-tested with or without the Control Node. This is to prevent water or dust penetrating through the control socket into the luminaire. Full type test shall be carried out by accredited laboratory and the complete type test report shall be submitted to LTA for acceptance.

2.1.10.5 The receptacle for the power and control cable for the luminaires shall be UV-stabilised, **IP 66** rated and come with a robust twist lock contacts for a reliable connection. The connection shall be made with a pre-terminated wire plug, properly rated for ease of cable installation to replace existing lighting with LED luminaries.

2.1.10.6 The receptacle shall come with pre-terminated with wire leads for ease of integration into new or existing light fixtures. It shall be available with 105^{o}C rated wire insulation.

2.1.10.7 The operating temperature shall meet minimum range from -40^{o}C to 85^{o}C.

2.1.10.8 The main power supply shall be 230 Volts AC and input supply shall be within 5-24 Volts DC.

2.1.10.9 The protection against mechanical impact shall be **IK 07**.

2.1.10.10 The receptacle shall be designed to retrofit with existing LED luminaire housing meeting Standards as stated in clause 2.1.2.

2.1.10.11 The luminaire used in Commuter Facilities shall have no control socket installed unless otherwise specified.

2.1.11 Installation of Control Node / Ground Control Node

2.1.11.1 A minimum clearance of 400mm is to be maintained on top of each LED luminaire to facilitate luminaire top cover opening and control node maintenance.

2.1.11.2 For site that required Ground Control Node (GCN), it will be single phase circuit with max. load up to 8A.

2.1.12 Upgradeability

2.1.12.1 The LED module shall be upgradeable on site after warranty period and further energy savings with better efficacy to ensure the lowest cost of ownership.

2.1.13 Earthing Terminal

2.1.13.1 A separate terminal for the connection of an earth continuity conductor, clearly and indelibly marked shall be provided.

2.1.13.2 All exposed metal parts and other parts accessible when the luminaire is opened for maintenance and liable to become ‘live’ in the event of an insulation fault shall be permanently and reliably connected to this earthing terminal.

2.1.14 Internal Wiring

2.1.14.1 The luminaires shall be completely pre-wired, requiring only the connection of the electrical power supply cables to the terminal block and the earth continuity conductor to the earthing terminal.

2.1.14.2 The wiring used shall be heat resistant type with a temperature rating of minimum 90^{o}C. The temperature rating shall be marked on the insulation. Samples of the heat resistant cable and cable manufacturer specification shall be submitted to LTA for acceptance.

2.1.14.3 All internal cabling shall be insulated stranded copper wire, rated at not less than 300 / 500 Volts for control cables and not less than 600 / 1000 Volts for power cables.

2.1.14.4 DC cable connector and internal wiring shall be provided between LED driver and LED module.

2.1.14.5 LED module and driver connector shall be plug and socket type.

2.1.15 LED Module

2.1.15.1 The LED module shall be of proven track records and type-tested to the requirements as specified. All tests shall be carried out by accredited bodies, laboratories or facilities certified under ISO/IEC 17025. The Contractor shall submit all relevant type test reports and track records.

2.1.15.2 The LED Module shall have the following features:

(a) Heat sink with high thermal dissipation properties;

(b) Provisions to prevent unauthorised removal;

(c) Corrosion resistant;

(d) Optics shall be UV resistant; and

(e) Operate in relative humidity of greater than 90.

2.1.15.3 The rated LED life L80/B20 shall be minimum 100,000 hours or higher at LED operating at 35^{o}C, unless otherwise stated.

2.1.15.4 The LED module shall be designed with adequate protection features to withstand the surges of lightning strikes and the frequent switching operation of the power supplies.

2.1.15.5 The LED modules shall be adequately supported to ensure that breakages do not occur through vibration or shock.

2.1.16 Test for Luminaire

2.1.16.1 The tests are as follows:

(a) Type Test for Luminaire

(i) A full type test shall be carried out for compliance with IEC 60598-2-3, including their latest revision / additions and amendments; and

(ii) For the humidity test, the test shall be carried out at a relative humidity around 95% and at an ambient temperature of 28^{o}C.

(b) Quality Control Tests

(i) A quality assurance scheme shall be established during the manufacture of the luminaires to ensure the quality of the product leaving the factory; and

(ii) The scheme shall cover the assurance of the quality of incoming materials, methods of welding, casting, moulding, forging, fabrication, assembly and final testing and inspection of the finished product.

(c) The luminaire shall also satisfy the following requirements:

(i) Photometric measurements of street luminaire to CIE 121 and to provide IES photometric data for lighting illumination design purposes (compliance with SS 531); and

(ii) Correlated Colour Temperature (CCT), colour chromaticity and Colour Rendering index (CRI) of LEDs to comply with SS 531 as well as to retain CCT & CRI over a given time duration of 100,000 hours.

(d) The lumen maintenance data at 100,000 hours shall comply to IES LM 80 with LED junction temperature in the LED module measured in accordance with relevant international standards such as JESD 51-50, JESD 51-51, etc.. Extrapolation techniques on the lumen maintenance data shall be in accordance with relevant international standard such as IES TM-21. The luminaire's operating temperature shall be based on 45^{o}C in accordance with thermal test condition with IEC60598-1; and

(e) A screening test in accordance to Clause 10.3 of IEC 62722-2-1 shall be conducted at an operating temperature of 45^{o}C and relative humidity of 90% to ensure that the luminaires can meet its projected 100,000 hours lumens maintenance during operation:

(i) Luminous degradation shall not exceed more than 5%; and

(ii) Change of chromaticity, max Δu'v' of 0.001.

2.1.16.2 Photometric data measurements and tests

2.1.16.3 The following tests and measurements shall be conducted to verify the luminaire photometric data:

(a) Isolux Diagram;

(b) Coefficient of Utilisation curves; and

(c) Polar Lighting Distribution Diagrams.

2.1.16.4 One (1) copy of all test certificates and reports certified by accredited laboratories in accordance with ISO / IEC 17025 shall be furnished to LTA for acceptance.

2.1.16.5 The luminaire housing and paintwork shall be subjected to Neutral Salt Spray Test for not less than 1,500 hours. The test result shall be submitted to LTA for acceptance.

2.1.16.6 Radiographic testing (RT)

(a) Contractor / lighting supplier will need to send their LED luminaires (one each of different housing size) upon the request of the Authority for at least one (1) time to Singapore accredited laboratory for this test;

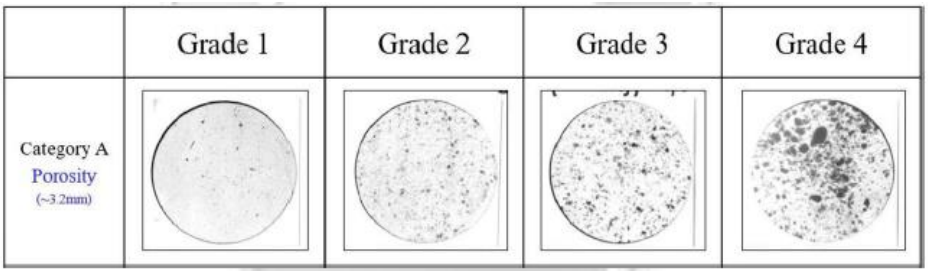
(b) The RT shall be conducted before and after the vibration tests (under Clause 2.1.2 (e) and (f)) to check on the acceptance of porosity level with reference to ASTM E505 standard;

(c) The RT shall be conducted on the bottom or top portions of the luminaire housing using an X-ray source;

(d) The RT results are evaluated with reference to ASTM E505 for the ease of reporting;

(e) ASTM E505 classifies the porosity defects under Grade 1 to 4 as follows for the casting thickness up to 3.2mm;

<u>Classification of porosity defects</u>



(f) The luminaire housing will be classified as follows:

(i) Function class 2: Critical areas like corner interface between the mounting bracket and luminaire housing on the bottom portion.

(ii) Function class 3: Non-critical areas not subjected to loading during operation like the top portion of the luminaire housing as well as away from the corner interface between the mounting bracket and luminaire housing on the bottom portion.

Acceptance Criteria

Acceptance limits for aluminium die castings products (with reference to ASTM E505) – for wall thickness up to 3.2 mm				
Type of fault	Quality grade A	Quality grade B	Quality grade C	Quality grade D
Discontinuity code A (Porosity)	1	2	3	4

Category and Grade requirements

General acceptance limits for tests on internal faults according to ASTM E505			
Function class 2		Function class 3	
Critical areas	Other areas	Critical areas	Other areas
Grade B or better	Grade C or better	Grade C or better	Grade D or better

General acceptance limits

2.1.16.7 The Contractor shall submit but not limited to the following:

(a) Luminaire manufacturer's sustainability policy and write-up;

(b) Luminaire manufacturer's sustainability Certification;

(c) Product Green Certification;

(d) Factory should be ISO 45001:2018 certified;

(e) Luminaire manufacturer's Sales and after sales support;

(f) Luminaire manufacturer's Quality process and write-up on how to ensure consistency in material quality;

(g) Luminaire manufacturer's shall provide the yearly Factory Audit Test which cover the latest ISO 9001 process, material selection, quality consistency, supplier selection, in-house safety test on IEC60598-1, etc. to the Authority for records; and

(h) International Dark Sky (IDA) Certificate.

2.1.17 Warranty

The LED luminaire manufacturer shall provide a warranty against all defective materials and workmanship for a minimum of ten (10) years after the date of Completion of the Works certified by LTA. The Deed of Extended Warranty shall be submitted to LTA upon the acceptance of the LED luminaires.

2.2 Luminaires Mounting in general

2.2.1 Means of Attachment

2.2.1.1 Attachment of the luminaires to its side entry bracket arm shall be by means of clamps / other securing mechanism and designed to accommodate bracket arm tube of relevant diameters as shown in the following table.

2.2.1.2 The securing mechanism of the luminaires shall be applied with medium strength thread lockers and shall be secured to the pole arm in accordance with the luminaire manufacturer's recommended torque setting.

2.2.1.3 Length of penetration of the side entry bracket arm shall be the relevant length as shown in the table. The mounting arrangement and wind resistant area of the luminaire shall be such as to withstand the 10 minutes mean wind velocity 22m/s (equivalent to 3 seconds gust basic wind speed of 37 m/s).

Rating of LED wattage	Diameter for side entry (mm)	Length of Penetration (mm)
< 43W 43W ≤ Luminaire ≤ 230W	>42 & ≤ 60 >50 & ≤ 60	80 100

2.2.1.4 All fixings that carry the weight of the luminaire and internal accessories shall be provided with suitable locking devices to prevent the dislodgement of any part of the luminaire by vibration either in service or during maintenance.

2.2.1.5 One (1) copy of wind speed test reports certified by accredited laboratories shall be furnished to LTA for acceptance.

2.3 Specification for Hot-Dipped Galvanised Octagonal Steel Poles Complete with Base Plates and Bracket Arms

Building Control Authority Singapore has mandated since 2015 that Eurocodes be adopted for Building Structure and Sub-structure Structural designs. Correspondingly SS EN 1991-1-4: 2009 was published as an identical implementation of EN 1991-14: 2005 Eurocode 1 - Action on Structure - Part 1-4: General Actions - Wind Action and adopted as a National Standard for industry use.

2.3.1 Poles and Brackets

All columns and brackets shall be tapered octagonal type as specified, consisting of hot dip galvanized interchangeable sections to comply in all respects to the drawings, Bill of Quantities and Notes. They shall be designed and manufactured to comply with BS EN 40-3-1: 2013; BS EN 40-3-2: 2013; BS EN 40-3-3: 2013; BS EN 40-2: 2004; BS EN 40-5: 2002; SS EN 1991-1-4: 2009 and NA to SS EN 1991-1-4: 2009. The base plate (for planted type columns), brackets arms or short spigot mounts shall be manufactured as separate units suitable for mounting or fixing onto the columns.

2.3.1.1 Pole Construction and Concrete foundation

(a) All poles including arms and associated mounting fixtures shall be designed to comply with the standards and guidelines issued by the Authority;

(b) The street lighting poles shall be continuously tapered hot-dipped galvanised octagonal steel poles consisting of two or more sections slip jointed, strained together to form a unitary pole of the desired height;

(c) The female (upper) section fits over the male (lower) section to build up the pole height;

(d) The female section shall overlap the male section by 1.7 (±20%) times the diameter of the female inner across flat dimension and shall be easily assembled on site by using simple tools without welding. The supplier shall provide a mark on the finished pole indicating the overlapped position of 1.75 X diameter;

(e) The poles shall be suitably designed for ground and flanged mounting. The J-bolt size shall be of 25mm diameter and of stainless steel grade SS 316. Each individual J-bolt shall be complete with two (2) flat washers and three (3) nuts and they shall be of the same stainless steel grade as the J-bolt;

(f) For planted pole, the pole shall be assembled with an appropriate size base (bearing) plate recommended by the pole manufacturer. Any deviation to the recommended base plate size shall be endorsed by a registered Civil Professional Engineer and subjected to the approval of LTA prior to the site installation;

(g) For planted pole, the concrete mix shall be poured into the pole pit to form the pole concrete foundation. The ratio of the mix shall be endorsed by a registered Civil Professional Engineer. The concrete grade strength shall be at least 30;

(h) For flange mounted pole, the pre-cast concrete foundation shall be exposed 50 -100mm above the finishing turf level;

(i) For flange mounted poles, the pre-cast concrete foundation that is abutting the edge of cycling path / footpath, shall be flushed with the finishing path level. The nuts and J-bolts shall be covered / plastered with cement;

(j) One (1) stainless steel grade washer and nut shall be placed on the underside of the base flange for verticality adjustment purposes, when needed. The two (2) nuts and one (1) washer on the skyward top of the base flange are meant for tightening and locking purposes;

(k) To fill up the gap between the foundation and the base plate of the pole, pressurised, flowable high strength non-shrink cementitious grout shall be used. Two (2) 9mm Ø diametral weep holes shall be provided at the pole abutting the base flange for drainage purposes;

(l) Mounting details including all data, calculations, imposed loads and forces and dimensional drawings for the foundations (cast in-situ and pre-cast concrete foundation) required for the poles shall be endorsed by a registered Civil Professional Engineer;

(m) The soil bearing capacity at the site shall be ascertained so that the foundations can be correctly designed;

(n) For poles with two or more sections, combining sections shall have a minimum thickness of 3.0mm. The bracket arms shall have a minimum thickness of 2.5mm. The planted base (bearing) plate shall have a minimum thickness of 4.0mm;

(o) Each section of the pole shall be made in such a way that only one (1) sheet of steel plate is used to form an octagonal pole segment. Welding shall be carried out along one longitudinal edge of the pole section only;

(p) Poles seam welding shall comply with the latest edition of EN 1011-2 by automatic continuous welding process. For longitudinal seam weld, minimum percentage penetration of the weld shall be 60%;

(q) A hole of 20mm diameter shall be provided at approximately 300mm below the top edge of the intermediate section. This hole shall be provided with a tight-fit rubber stopper to prevent water from entering the pole;

(r) As bitumen coating shall be applied internally and externally to the buried butt end of planted type poles, extra care shall be taken during the transportation and storage to prevent the poles from being smeared by the bitumen coating. The component sections of the pole shall not be nested inside one another. The poles shall be packed for transportation and storage in such a way that the clean galvanised surfaces are not abrading against one another, below or above the bitumen coating region. It is mandatory that the bitumen coated regions be dipped in lime solution to minimize smearing. Wrapping of the lime dipped bitumen portion with newspapers is not acceptable, as the removal of the latter will be messy and fragmentarily incomplete in the absence of thorough field supervision. For this purpose, good quality polyvinyl shrink wrap shall be employed to insulate and protect the bitumen coated regions from contamination smear upon one another. This has the further advantage of ease of unwrapping with minimal damage to the bitumen coating during installation;

(s) The material used for strapping the poles together during the delivery shall be of non-rust type. This is to prevent rust stains transferred from the straps due to weathering if stored for an extended period; and

(t) Pole loadings shall conform to BS EN 1090-2 and all relevant local Code of Practice. Lighting Pole and all mounting provision (including accessories) shall be provided.

2.3.1.2 Materials

(a) The poles shall be manufactured from steel as specified in the latest edition of BS EN 10025;

(b) The base plates shall be manufactured from mild steel; and

(c) The bracket arms shall be manufactured from materials as specified in the Drawings attached.

2.3.1.3 Design and Dimensions

(a) The general design and dimensions shall be as closed as possible to the Drawings attached and certified by a registered Mechanical Professional Engineer;

(b) The poles with bracket arms shall be designed to withstand the 10 minutes mean wind velocity 22m/s (equivalent to 3 seconds gust basic wind speed of 37m/s);

(c) Wind Loads shall be obtained using the design wind pressure as obtained by the following formula as specified in BS EN 40-3-1 with design parameters modified for local conditions in accordance with NA to SS EN 1991-1-4:2009:

$q(z) = \delta \times \beta \times f \times Ce_{(z)} \times q_{(10)}$

where:

q(z) is the characteristic wind pressure in N/m^2 for any particular height above ground, z (m)

$q_{(10)}$ is the reference wind pressure

δ is a factor depending on the column size

β is a factor depending on the dynamic behaviour of the column

f is a topography factor and

$Ce_{(z)}$ is a factor depending on the terrain of the site and height above ground z. Only two (2) terrain categories shall be adopted for local with roughness parameters in accordance with Table NA. 1 of NA to SS EN 1991-1-4: 2009. When a site is located at a very exposed area within 2km from the sea and subjected to an extremely high wind pressure, the terrain category and the value of $Ce_{(z)}$ to be adopted shall be agreed with LTA.

$q_{(10)}=0.5 \rho \times (C_s)^2 \times V_{ref}^2 \ N/m^2$

where:

ρ is the air density and shall be taken as 1.194 kg/m^3

C_s should be taken as $\sqrt{0.92}$ for a mean return period of 25 years

V_{ref} is defined as the 10 minutes mean wind velocity having a mean return period of 25 years and shall be taken as 22m/s (equivalent to 3 seconds gust basic wind speed of 37m/s); and

(d) The structural design of the pole shall be verified by calculation in accordance with BS EN 40-3-1 and BS EN 40-3-3 with partial load factors Class B and maximum deflection Class 2. Particular attention is drawn to the reinforcement of the door opening which is a highly stressed zone. Rigorous structured analysis of the door compartment in accordance with BS EN 40-3-3 must be clearly identifiable in the structural calculations. The terrain / height parameters must also be clearly shown in the design calculation to enable wind load verification in compliance with BS EN 40-3-1.

2.3.1.4 Supplementary Loads

(a) Provision must be provided for Street Lighting Pole to cater for contemporary banners, equipment, posters, etc..

(b) Street Lighting Pole shall be robust and not oscillate excessively when mounted with these supplementary banners.

(c) The pole manufacturer must submit supporting structural calculations to verify that these supplementary loads have been adequately considered.

2.3.1.5 Tolerances

(a) Width or Diameter - The tolerance on the width or diameter of the section shall be ±4% (per BS EN 40-2) of the width or diameter.

(b) Thickness - The tolerance on the thickness of the material shall be ±0.22mm of the thickness (per BS EN 10051).

(c) Straightness - The completed poles shall not deviate from straightness by more than an amount calculated at the rate of 3mm per metre (per BS EN 40-2). This also applies to the complete poles and bracket assembly.

(d) Bracket Arms - The bracket arms shall be heavy duty hot-dipped galvanised steel fabricated in accordance with the design Drawings with particular attention to the following areas:

(i) smoothness of curvature of bracket arms;

(ii) tolerance of curvature - which shall be within ±2% of the radius of curvature;

(iii) the angle of tilt at the end of the bracket arm - which shall be within ± two (2) degree per BS EN 40-2 of the tilt. The angle of tilt other than 4m / 5m arm shall be five (5) degrees and measured with the bracket arm installed on the poles and measurements made with a calibrated spirit-level at any point within 150mm from the end of the bracket arm; and

(iv) the shape of the bracket arms shall be octagonal throughout except the spigots, which shall be tubular end as shown in the Authority's Drawings.

2.3.1.6 Design of Pole Door and Locking System

(a) A door shall be provided with a locking device over the door opening of each pole as shown in the Drawings. The triangular locking device shall be made of stainless steel as specified in the Drawings. The locking device shall be properly assembled. The triangular bolt shall be jammed at one end so that it will not be dislodged when it is fully opened;

(b) Pole doors shall be flushed with the poles with ingress protection in accordance with BS EN 40-2 of **IP 3X**;

(c) An aluminium name plate of size 50mm x 75mm shall be installed on the outer surface of the pole door. The following details shall be engraved on the plate:

(i) Name of Manufacturer;

(ii) Year of Manufacture;

(iii) Batch Test Number; and

(iv) Height of Pole (e.g. 6m, 8.5m, 10.2m).

(d) The rivets used to fix the name plate must be of non-rust type; and

(e) The pole door shall be hinged at the top. The hinges shall have minimum opening of the door of 180^{o}.

2.3.1.7 Baseboard

(a) During installation, a cut-out unit will be installed inside the poles by means of three (3) M12 25mm long screws;

(b) A fixing device, which could be a perforated plate made of hot-dipped galvanised steel shall be fixed in the pole directly facing the pole door as part of the pole. The cut-out unit shall be mounted directly onto the fixing device. The fixing device shall be able to cater for different types of cut-out units; and

(c) Alternatively, a baseboard made of hot-dipped galvanised steel shall be provided and mounted in each pole for fixing of cut-out unit.

2.3.1.8 Earthing Terminal

An earthing terminal in the form of a M8 bolt in accordance with BS EN 40-2: 2004 made of SS316 stainless steel material shall be provided close to the door opening inside the pole. In addition, it shall have substantial contact surface for the attachment of an earthing lead. Two (2) suitably sized washers and two (2) nuts shall be provided for each bolt. Each pole shall be provided with four (4) bolts. The bolts, nuts and washers shall be made of stainless steel.

2.3.1.9 Labelling Tag

The luminaire's brand, wattage and LED CCT value shall be cable tie to the pole earth bar to facilitate the maintenance team / inspector to identify the luminaire mounted on the pole. The tag shall be of waterproof type.

2.3.1.10 Protection against Corrosion

Individual sections of the pole, base plate and bracket arm shall be protected against corrosion by hot-dipped galvanisation internally and externally in accordance with the latest edition of BS EN ISO 1461. All welding works shall be done before the galvanisation.

(a) No zinc flux shall be left inside the pole or bracket arm after galvanisation. The presence of these impurities can pose a problem in the installation of pole internal wiring;

(b) The treatment prior to galvanisation shall include degreasing, pickling, rinsing and fluxing; and

(c) The minimum average zinc coating weight shall be 610 grams per square metre.

2.3.1.11 Extra Protection against Corrosion at the Pole Base

(a) A coat of bitumen shall be applied internally and externally to the base section on top of the galvanised coating by means of dipping. It shall be applied over the length of the planting depth and for a distance of 200mm (and not more than 250mm) above the planting depth. The total length to be applied with the bitumen coating shall be shown in the following table. A circular marking shall be made on the poles during manufacturing to indicate the level of the planting depth;

Type of pole (m)	1.5#	2.0#	2.5*	2.5	3.0	3.5
Recommended planting depth	0.75	0.75	0.75	0.75	0.75	0.75
Length of bitumen	0.95	0.95	0.95	0.95	0.95	1.10

*Flashing Beacon Pole
#Tubular Pipe

Type of pole (m)	6.0	8.5	10.2	12.0	13.0
Recommended planting depth	1.4	1.5	1.7	1.7	1.8
Length of bitumen	1.6	1.7	1.9	1.9	2.0

(b) The bitumen used shall conform to the latest edition of BS 4147 or ASSHTO M190-70;

(c) The bitumen shall be heated in a tank to a temperature of approximately 220^{o}C before dipping;

(d) The dry film thickness of the bitumen coating shall be at least 762um; and

(e) A layer of lime powder shall be applied to the bituminous coating for easy handling of poles.

2.3.1.12 Aesthetic Appearance of the Finished Surface

(a) The poles and bracket arms shall be of prime finish and good uniformity; i.e. free from injurious defects, such as blister, flux and non-coated spots, white rust, peeling of bituminous paint coating, etc.;

(b) The galvanising and bituminous appearance of poles and brackets supplied shall not be inferior to the sample submitted for evaluation. If in the opinion of LTA that the galvanising and bituminous finish of the poles and brackets is inferior to the sample supplied, LTA shall have the right to reject the inferior poles or the entire lot; and

(c) The Pole supplier / Contractor shall apply the transparent anti-stick paint when instructed by the Authority.

2.3.1.13 Pole internal wiring

(a) An adequate length of XLPE/PVC sheath cable, 3-core, 2.5mm^2 rated at 600 / 1000 Volts, shall be provided for the connection between the fuse cut-out unit and the luminaire. The cables shall be properly supported to prevent undue strain on the cable terminations. The cable colour identification shall comply with the latest Energy Market Authority (EMA), Singapore requirements / edition of SS 638; and

(b) The cables shall be manufactured to the latest edition of IEC 60502-1.

2.3.1.14 Test and Test Certificates

(a) All sample poles and bracket arms shall be submitted to an accredited testing laboratory for the following tests:

(i) Dimensional and Weight Measurements of pole & bracket;

(ii) Deflection Type Test (per BS EN 40-3-2: 2013): The serviceability & structural test loads for the verification test are the characteristic dead and wind loads specified in clause 3 & 4 of EN 40-3-1: 2013;

(1) Serviceability requirements:

Horizontal deflection

The temporary horizontal deflection of the luminaire connection caused during the load test by the incremental load due to the horizontal forces corresponding to the test load shall not exceed the value given in Table 3 of BS EN 40-3-3 Class 2 [Max horizontal deflection 0.06 (h+w)].

Vertical deflection

The temporary vertical deflection caused by vertical force corresponding to the luminaire or aspect mass shall not exceed 0.025w indicated in Clause 6.5.2 of BS EN 40-3-3.

h - is the nominal height of the lighting column (in mm) as defined in EN 40-1.

w - is the bracket projection (in mm) as defined in EN 40-1.

(2) Structural requirements:

For steel lighting pole the residual deflection after removal of the test load shall be no greater than 10% of the deflection caused by the test load.

(3) Application of forces:

The forces shall be applied to act so that the moments caused at the critical sections in the pole are at least equal to the moments resulting from the test loads. At all other points the moments shall be not less than 95% of the moments resulting from the test loads.

The horizontal or vertical forces shall be applied in stages by means of at least five (5) approximately equal incremental loads up to the test load. At the test load the deflection of the luminaire connection shall be measured and entered in the test report.

After unloading from the horizontal or vertical deflection test, the residual linear horizontal or vertical deflection shall be measured and recorded.

(iii) The position of the door relative to the direction of the horizontal loading shall be in the most onerous position allowed in design and the position shall be stated. Where a bracket is used the position of the bracket projection relative to the position of the door shall be stated;

(iv) Before carrying out the tests, the lighting pole may be loaded once and then unloaded provided that the applied load does not exceed 50% of the test load;

(v) Galvanising Test: The poles and brackets shall be subjected to the galvanising thickness test as laid down in the latest edition of BS EN ISO 1461;

(vi) Bitumen Test: The bitumen coating on the pole base shall be subjected to thickness test as laid down in the latest edition of BS 4147 or ASSHTO M190-70;

(vii) Material Test: Steel material used for the manufacturing of poles and brackets shall be subjected to test for compliance with the latest edition of BS EN 10025 Grade S275 JR. The test method and the reference standards shall be subjected to the approval of LTA;

(viii) Welding Test: All welded portions of the pole and bracket shall be subjected to a relevant welding test. The supplier shall state the reference standard and the strength of the welded joint together with the tender. The reference standard shall be the latest relevant British Standard. The reference standard and the strength of welded joint shall also be subjected to the approval of LTA;

(ix) For longitudinal seam weld, the reference standard shall be the latest edition of EN 1011-2; i.e. by transverse tensile test where results shall not be less than 60% of specified minimum value of parent material;

(x) Mechanical Property Test: The accredited testing laboratory for this test shall cut off a small piece of steel plate of adequate size from the base of the sample poles; and

(xi) The tensile strength and yield strength of the sheet metal shall be measured. The test results shall comply with the limits specified in the latest edition of BS EN 10025 Grade S275JR steel as follows:

	BS EN 10025 S275 JR
Tensile strength	(t<3) 430 - 580 N/mm² (3 ≤ t ≤ 100) 410 - 560 N/mm²
Yield strength	≥ 275 N/mm^2

(b) Test report for the above shall be submitted by the supplier / manufacturer together with the batch delivered. Otherwise, the batch of delivery will not be acceptable.

2.3.1.15 Batch Testing

(a) For each batch of delivery, the supplier shall submit samples to the accredited testing laboratory for testing and inspection on the quality of the products. The delivery will not be accepted by LTA unless the sample passes the batch tests; and

(b) For every batch delivery, the number of samples to be tested shall be in accordance with the latest edition of EN ISO 1461.

2.3.2 Concrete Test Cubes for pole foundation

(a) Four (4) test cubes shall be made from the concrete used in each of the preliminary test piles and working pile as directed by LTA. If a concrete footing is cast separately from a preliminary pile or a working pile, a further four (4) cubes shall be made from this concrete; and

(b) The test cubes shall be sent to accredited testing laboratory and tested with accordance to the latest edition of BS 1881.

2.3.3 Pole label

(a) Comes in one-piece for ease of on-site application: White-retro reflective sheeting as the background and roll laminated with red-coloured cast vinyl film on top;

(b) The Cast-Vinyl Film shall be of Pantone colour code 187c and have a thickness of 0.05mm, with pressure sensitive adhesive designed for permanent graphics;

(c) The White retro-reflective sheeting shall comply to Type 11 sheeting of ASTM D4956;

(d) The whole piece of label shall have a minimum warranty of seven (7) years from the sheeting manufacturer. Quality audit must be performed by the sheeting manufacturer to ensure proper fabrication and conformance to specification;

(e) Each pole label has to be silkscreen printed with the Sheeting Manufacturer's initials as well as the year of manufacture on it. The silkscreen printed initials / year of manufacture should not affect the visibility of the label and therefore should be kept at a size lesser than 3mm x 10mm to be printed at the bottom of the alphabets / numerals;

(f) The overall dimension of the Type A label (meant for pole height of 8.5m and above) shall be 60mm x 110mm. The height of the alphabets / numerals within the label shall be 100mm. The four (4) corners of the label shall be curved;

(g) The height of the alphabets / numerals of the Type A1 label shall be 100mm;

(h) The overall dimension of the Type B label (meant for pole height of 6.0m and below) shall be 50mm x 92mm. The height of the alphabets / numerals within the label shall be 85mm. The four (4) corners of the label shall be curved;

(i) The height of the alphabets / numerals of the Type B1 label shall be 85mm;

(j) All lighting poles shall be conspicuously numbered using two (2) sets of pole label and a round sticker bearing a black arrow against a yellow background that indicates the direction of the lighting control box. Samples of the number labels shall be submitted to LTA for approval;

(k) The pole label colour table for respective system is as follows:

Type of pole / system	Colour (Code)		Remarks
	With background	Without background	
Conventional Street Lighting	White in red background (4090 & 1172)	-	Type A & B
Decorative & multi-function pole	-	Red / White (4092 / 4090)	Type A1
Commuter Facilities (e.g. Cycling Path / Footpath)	-	Green (4097)	Type A1
Flashing Beacon	-	White (4090)	Type A1
CIPC	-	Orange (4084)	Type A1
iEUP	-	Yellow Green (4083)	Type A1

2.3.4 Visual Enhancement Retro-reflective Sticker

(a) The label shall have black arrows with yellow retro-reflective background. The width of the label shall be 300mm (bottom piece) / 500mm (bus route piece) and go around the entire pole (ranging from 600mm - 800mm length) using flexible prismatic reflective sheeting. The yellow retro-reflective sheeting shall comply to Type 4 sheeting of latest ASTM D4956;

(b) The whole piece of label shall have a minimum warranty of five (5) years from the sheeting manufacturer. Quality audit must be performed by the sheeting manufacturer to ensure proper fabrication and conformance to specification;

(c) Each label must be silkscreen printed with the Sheeting Manufacturer's initials as well as the year of manufacture on it. The silkscreen printed initials / year of manufacture should not affect the visibility of the label and therefore should be kept at a size lesser than 5mm x 20mm to be printed at the bottom of the label;

(d) The bottom piece label shall be pasted at 800mm (measured from finishing floor level to bottom of sheet) and the bus route piece label shall be pasted at least 1,600mm (measured from finishing floor level to bottom of sheet) when pole with less than 600mm setback distance from road kerb;

(e) To use this label, written approval must be obtained from LTA prior to the installation of this sticker; and

(f) Epoxy Sealant shall be applied on the overlap joint upon completion of each sheeting application.

2.4 LV Cables and Conductors

2.4.1 Armoured Cable

2.4.1.1 Armoured cables shall be used for underground cables laying and comply with IEC 60502. Cable insulation resistance test shall be carried out to laying and after every length has been laid and after every joint has been completed.

2.4.1.2 All multi-core armoured cables shall be single galvanised steel wire type. The armoured cables shall comply with BS 5467 for XLPE insulated type and BS 6724 for XLPE insulated with LSOH type. Single core armoured cables shall be of non-magnetic type.

2.4.1.3 Jointing and terminating accessories shall include all necessary internal and external luminaires and insulating materials. They shall also include precisely dimensioned cable stripping ferrules and the mechanical gland designs. It should be possible to erect and dismantle compression glands without the use of special tools.

2.4.1.4 All cables entering or leaving equipment shall be provided with separate termination and be spaced so that any one cable out of a number of such cables can be removed without disturbing the rest.

2.4.1.5 Compression glands shall comply with the latest edition of BS 6121 and shall be designed for the termination and clamping of armour wires and shall be fitted with an earth bond terminal attachment. The function of the gland shall be to secure the armour wires and provide electrical continuity between the armour and the threaded fixing component of the gland and to give water-tight seals between the cable outer sheath and the gland and between the inner sheath and threaded fixing components. The armour for cables shall not be used as circuit protective conductor for carrying earth fault current. All cable glands shall be complete with low smoke zero halogen cable shroud.

2.4.1.6 The C.P.C. (earth cable) shall be bonded to the brass cable gland by stainless steel bolt and nut.

2.4.1.7 All cables terminations shall be provided with cable lug and approved PVC colour sleeve.

2.4.1.8 All underground cables shall be laid in Class B type heavy-duty UPVC pipes of nominal diameter 100mm comply with the latest edition of SS 141. Heavy-duty hot-dipped galvanised pipe shall be used for concrete surface or crossing the drain.

2.4.1.9 Cables used for street lighting poles and zebra-crossing beacon lighting poles shall be of three-phase 4-cores, 16mm^2 XLPE/SWA/PVC cable c/w separate 16mm^2 yellow-and-green PVC C.P.C. (earth cable). The cable colour identification shall comply with the latest Energy Market Authority (EMA), Singapore requirements / edition of SS 638.

2.4.1.10 Cables used for commuter facilities equipment shall be of either single-phase 3-cores, 4mm^2 or 6mm^2 or 10 mm^2 XLPE/SWA/PVC cable. The cable colour identification shall comply with the latest Energy Market Authority (EMA), Singapore requirements / edition of SS 638.

2.4.1.11 If two (2) different versions of cable colour code are used in an installation, a warning notice shall be affixed at or near the appropriate lighting control box / pole / lighting fixtures. The warning notice shall be as follow:

CAUTION

This installation has wiring colours to two versions of Code of practice for electrical installations (SS 638).

Great care should be taken before undertaking extension, alternation or repair that all conductors are correctly identified.

2.4.2 Cable Trenches

2.4.2.1 The latest “Code of Practice for works on public streets” and Standard Design Road Element (SDRE) published by LTA shall be observed and complied when carrying out excavation works on the cable trench.

2.4.2.2 The depth of the cable trench shall be at least 1,000mm from the finished ground / road level to the top of the UPVC pipe on turf, pavement and roads. All trenches shall be of sufficient width to allow minimum spacing of 50mm between pipes.

2.4.2.3 Trenches along sidetables shall be at least 600mm clear of the edge of the carriageway or kerb and they shall be at least 500mm away from other services but not limited to the following: high-tension cables, gas and water mains, telecommunication cables or SCV cables. The side tables disturbed shall be made good to the satisfaction of LTA / relevant authorities upon backfilling the trenches.

2.4.2.4 Trenches shall be kept as straight as possible unless obstructed by existing services.

2.4.2.5 The bottom of the cable trench shall be level and smooth without stones or hard lumps. In rocky or hard ground, a 75mm layer of sand or granite dust shall be laid along the trench bottom.

2.4.2.6 Trial holes and manual excavation to locate services in the vicinity of the proposed trenches shall be provided for.

2.4.2.7 Contractor shall dispose water in the trenches.

2.4.3 Cable Laying

2.4.3.1 When laying of underground cable at backlane is not permissible due to other services at the backlane, the cables shall be run in surface GI conduit subject to LTA’s approval.

2.4.3.2 The minimum bending radii of the cables as specified by the manufacturers shall be strictly observed. Cables shall be bent as little as possible and always in the same plane to avoid twisting of the cables. During laying, there shall be no 'figure eight-ing' of cables and all bends shall be avoided by using the requisite number of men, rollers and tools as required and pulling from joint to joint. LTA reserves the right to stop any cable laying work if there are inadequate means or equipment to carry out the work satisfactorily.

2.4.3.3 Pulling ropes shall be attached to the free ends of power cables by means of an approved "pulling eye" as supplied by the cable manufacturers for this purpose. Cable jacket and tape armouring shall be cut back clear of the pulling eye and under no circumstances shall the pull force be transmitted to the jacket or tape armouring.

2.4.4 Backfilling

2.4.4.1 After the UPVC pipe is laid, the earth filling shall be selected from earth free from stones and other sharp objects. The filling shall be compacted around the heavy-duty UPVC pipe and finished off at a level of 250mm above the pipe.

2.4.4.2 PVC cable warning slabs shall be laid in an approved manner on top of the earth filling directly over the pipe / cable (at pole entry slot hole). These slabs shall be appropriately labelled and subject to approval by LTA.

2.4.4.3 The earth filling shall extend to 250mm above the PVC cable warning slabs and shall not contain stones of dimension exceeding 75mm. The filling shall be compacted by means of hand hammer.

2.4.4.4 The trenches shall then be filled with soil in layers of not exceeding 300mm in depth, each layer being thoroughly rammed by means of mechanical rammer before the next layer is placed over. The filling shall allow for probable subsidence, after which any excess soil shall be removed.

2.4.4.5 Regular inspection to be carried out on the backfilling work during the Defects Liability Period (DLP) and shall top up the backfill should subsidence occur.

2.4.5 Pipes Crossings / Pipe along carriageway

2.4.5.1 All underground cables shall be laid in heavy-duty UPVC pipes of nominal diameter 100mm.

2.4.5.2 Pipes shall be encased in concrete and normally go under all obstructions such as mains, sewers, drains, conduits and the like which cross the cable route in these cases, the trenches shall be carefully ramped so that the installed pipes will ramp gradually and rise to the original level after crossing the obstructions. Where it is not practical to go underneath culverts and drains, pipes shall with the approval of LTA go over them but care shall be taken to construct concrete ramps on both sides and steel plates or channel iron to protect the pipes.

2.4.5.3 The heavy-duty UPVC pipes shall be encased with at least 100mm thick cement dust all round.

2.4.5.4 The composition of cement dust consists of one (1) part of cement and 10 parts of granite dust.

2.4.5.5 The cement dust mixture shall be sprinkled with water and compacted in layers to achieve a hardened layer.

2.4.5.6 PVC cable warning slabs shall then be laid above the heavy-duty UPVC pipes with a layer of 250mm soft earth / sand.

2.4.5.7 The different kind of material, base course and asphalt shall then be laid in accordance with Code of Practice for road opening works published by LTA.

2.4.6 Cable Pipes and Ducts

2.4.6.1 All cable pipes and ducts shall be free of obstructions and sharp objects.

2.4.6.2 The pipes shall be laid as straight as possible and shall be continuous and extended to the nearest existing street lighting pole that is not affected by the works.

2.4.6.3 Two (2) nos. nominal diameter 100mm heavy-duty UPVC pipe complying to SS 141, Class B type with pulling ropes / cables / pilot wire shall be provided in turf area / pavement / roadways or tarmac area unless otherwise specified in the street lighting / footpath / cycling path design layout.

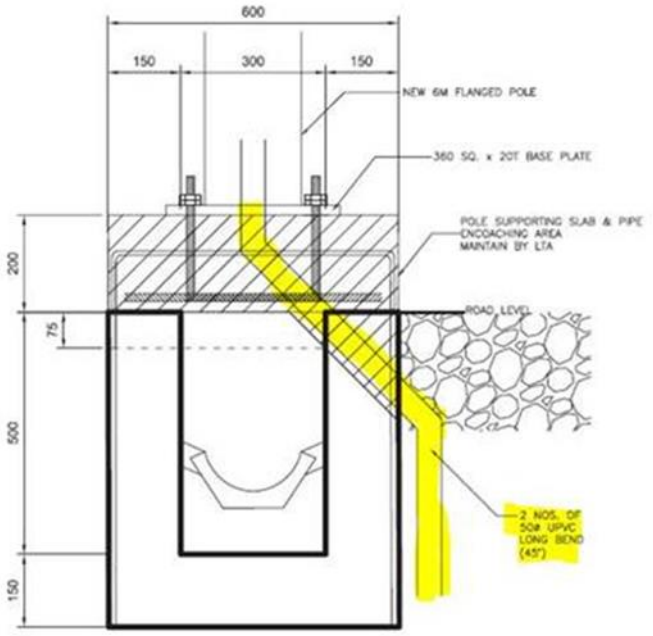
2.4.6.4 Three (3) nos. nominal diameter 100mm heavy-duty UPVC pipe complying to SS 141, Class B type with pulling ropes / cables / pilot wire encased with concrete shall be provided at road crossing (which includes driveway entrances) unless otherwise specified in the street lighting / footpath / cycling path design layout.

2.4.6.5 Any spare UPVC pipe(s) at road crossing shall be extended to the nearest lighting pole and covered with end caps at both ends.

2.4.6.6 Before being pulled into these, the cables shall be coated with petroleum jelly or an approved method such as covering the entry of the opening with a piece of cloth or rag to ensure no damage to the sheath when a cable is being pulled in. A guide pulley shall be employed to prevent the cables from fouling the opening and causing damage to the coating and armour of the cable.

2.4.6.7 The location of the road crossing pipes shall be indicated by a 50mm diameter aluminium disc with a red arrow and black words “Public Lighting Cable” or “Cycling Path Lighting Cable” or “Footpath Lighting Cable” and it shall be secured on both (side of the) road kerbs. The lettering shall be at least 6mm high and 3.5mm wide.

2.4.6.8 For lighting pole that is directly mounted on top of the drain, the UPVC pipe(s) shall be laid as shown.



2.4.7 Conduits

2.4.7.1 General

(a) All GI conduits shall be earthed in accordance with the latest edition of SS 638;

(b) Conduit entry to lighting junction / control box shall be by means of a coupling and a hexagonal male brass bush; and

(c) GI conduits shall be run truly vertical, horizontal or parallel with the features of the viaduct / flyover. Conduit shall run continuous between outlets with minimum number of bends.

2.4.7.2 Galvanised Iron Conduits and Accessories

(a) All conduits shall be heavy gauge, hot-dipped galvanised welded steel, manufactured in accordance with the latest edition of BS 4568, Part 1 and Class 4 type;

(b) Conduits shall be free from internal burrs, fins and the like which may cause damage to cables;

(c) Colour of conduits shall be to LTA's acceptance. Appropriate surface preparation shall be carried out prior to the painting of the final coating;

(d) All circular junction boxes, pull boxes, solid elbows and inspection boxes shall be made of malleable iron type and of standard pattern with spout to the latest edition of BS 4568 Part 2;

(e) Circular junction boxes, pull boxes and inspection boxes shall be provided with heavy gauge lids; and

(f) Conduit outlet (knockout) boxes shall be of hot-dipped galvanised steel complete with adjustable lug, ample knockouts and brass earth terminals fitted in the base and shall comply with the latest edition of BS 1363 and BS 4662.

2.4.8 Reinstatement Work

Unless otherwise specified, all paved / tiled and unpaved surfaces, roadways and drains shall be reinstated to the satisfaction of LTA.

2.4.9 Jointing of Cables

2.4.9.1 Cable joints are not permitted without the written approval from LTA.

2.4.9.2 If jointing of cables is inevitable, qualified jointers registered with the SPPG shall carry out cable-jointing work.

2.4.10 PVC Cable Warning Slab

2.4.10.1 The PVC cable warning slab shall be made of high impact resistant hard PVC and manufactured to the latest ONORM E6530, ASTM D1525 and ASTM D3045 specification. Use of regenerated PVC is strictly forbidden. They shall be of black in colour. Each warning slab shall be 1,000mm long and 172mm or 272mm wide and marked indelibly with the following "DANGER ↯ LTA LT CABLES". The lettering shall be at least 30mm high and 18mm wide. Each warning slab shall be laid in accordance with the manufacturer's recommendation to form a continuous chain.

2.4.10.2 Adjacent warning slabs shall also be linked if two slabs are placed side by side to cover the width of the trench.

2.4.10.3 The warning slab shall be resistant to chemical influences likely to be encountered when buried in the ground. They shall have a hardness of not less than 8KN/cm^2 with dielectric strength of not less than 40KV/mm and elasticity the order of 200,000N/cm^2. They shall not soften at temperatures of up to 70^{o}C.

2.5 Overhead Line

For temporary diversion of lighting poles, where overhead lines are used, five (5) nos. (for three-phase) or three (3) nos. (for single-phase), single core, 10mm^2 PVC/PVC cable c/w separate 10mm^2 yellow-and-green PVC C.P.C. (earth cable) shall be used.

2.6 PVC and PVC / PVC Cable

2.6.1 PVC / PVC cables and PVC cables shall be 600 / 1000 Volt and 450 / 750 Volt grade respectively consisting of high conductivity copper wire.

2.6.2 The cables shall be manufactured to the latest edition of SS 358-3 / BS 6004 and IEC 60227-3.

2.7 Lighting Control Box

2.7.1 General

2.7.1.1 All components of the lighting control box shall be housed in a weatherproof housing of robust construction. The lighting control box to be constructed in accordance to type tested latest edition of BS EN61439-1 and IEC 439-1. The housing shall be provided with a watershed top or 30^o slope of one side as instructed by the Authority. The housing must have a Degree of Protection of not less than **IP 55** IEC Publication 529: 1989.

2.7.1.2 An additional pitch roof of 30^o slope of one side shall be added to the existing control box as and when instructed by the Authority.

2.7.1.3 Three-phase lighting control box shall be rated at 63 Amps. HRC fuses shall be used for the protection of the circuits. Each lighting control box shall contain no more than three (3) outgoing circuits serving the lighting system. 3-poles, three-phase contactors shall be used in conjunction with Lighting Control Box Controller (LCBC) for the control of the street lighting, footpath and cycling path lighting.

2.7.1.4 Single-phase lighting control box shall be rated at 32 Amps. HRC fuses shall be used for the protection of the circuits. Each lighting control box shall contain no more than three (3) outgoing circuits serving the lighting system. 2-poles, single-phase contactors shall be used in conjunction with LCBC for the control of commuter facilities system.

2.7.1.5 The lighting control box shall be provided with a root of ample strength and suitable for mounting on a concrete foundation. A concrete plinth of minimum height of 300mm shall be provided for mounting of the lighting control box.

2.7.1.6 A space shall be reserved in the lighting control box for future KWh meter installation. The control box door shall come with a transparent UV resistance window with neoprene seal for future meter reading purpose.

2.7.1.7 The door lockset of the lighting control box shall use master key “A” series cam lock.

2.7.1.8 The control box shall be of double leaf door type.

2.7.1.9 All electrical accessories such as HRC fuses, MCBs, ELR, LCBC, contactors, and electrical wirings in the lighting control box need to be neatly labelled.

2.7.1.10 Inside the lighting control box at the bottom where the incoming underground cables are located, it shall be filled with “washed” sand to appropriate height.

2.7.1.11 The supplier of the lighting control box shall have proven track records in the last three (3) years.

2.7.2 Housing

2.7.2.1 All components of the housing except the housing bolts and nuts shall be made of at least **aluminium alloy AA1100**. The housing bolts and nuts shall be of stainless steel. The four (4) pillars of the housing shall be rounded with radii of not less than 25mm. This shall be extruded from 3mm thick aluminium in one homogeneous piece according to the latest edition of BS EN 1484 to provide a better mechanical strength. Roof and all other panels shall be ‘pressed-form’ from a whole sheet of 3mm thick aluminium plate. All drilling, punching, cutting, bending and welding parts shall be completed and all burrs removed before the electrostatic powder coating process is applied.

2.7.2.2 The housing shall be electrostatically coated with pure polyester powder of thickness between 80 microns and 100 microns. Materials shall be chemically treated before and oven baked after the powder coating process. The powder coating shall be weather resistant.

2.7.2.3 Adequate ventilation shall be provided to permit natural circulation of air. Temperature-rise Limits of maximum 600 Amp rating to the latest edition of BS EN61439-1 and IEC 439-1. The ventilation apertures shall be suitably screened to prevent the entry of rain, vermin and other foreign bodies.

2.7.2.4 The housing shall be able withstand a high voltage surge of 12kV to the latest edition of BS EN61439-1 and IEC 439-1.

2.7.2.5 The colour of the lighting control box shall be RAL 7039 for the pillars and roof and RAL 7032 for the others.

2.7.3 Danger Notice

A 'Danger' notice shall be provided, stuck on the inside and outside of each door of the lighting control box.

2.7.4 Data Plate

2.7.4.1 A data anodized plate shall be fixed to each control box detailing the following information:

(a) LTA Logo;

(b) Manufacturer's name;

(c) Contract Number;

(d) Date of manufacture; and

(e) Serial Number.

2.7.4.2 A sample shall be submitted to LTA for acceptance.

2.7.5 Door and Door Hinges

In general, the door shall be suitably designed to provide maximum protection from heavy driving rain and inclement weather. Access to the front of the control box shall be by means of hinged doors. The hinges on the door shall not project outside of the shell and shall be secured by open flange fasteners. These fasteners shall be flushed and not be seen on the outside of the door. The hinges must enable the door to be swung open not less than 120^{o} from the closed position. Doors shall be easily detachable by lifting of pins from the hinges without having to use special tools and to be secured by medium security cam locks.

2.7.6 Pillar

The pillar shall be provided with a root of ample strength and suitable for mounting on a concrete / foundation at ground level. A removable apron of approximately 210mm with door closed height shall be provided at the front of the pillar to facilitate direct installation and jointing of cables to the distribution units. Sufficient number of UPVC pipes shall be provided for cable entries into the box (refer to 2.7.8.3 for apron height).

2.7.7 Provision for plastic pocket to house single line drawings (endorsed by LEW of appropriate grade) fitted inside the interior of the lighting control box door.

2.7.8 Provision for Tapping Temporary Supply from the lighting control box

For the purpose of tapping temporary supply from the lighting control box, the design of the lighting control box shall also incorporate the following:

2.7.8.1 A 65mm diameter opening shall be provided on both right and left hand side-panels of the housing. This opening shall allow temporary overhead electrical wires to be brought into the box and shall be covered with aluminium plate when not in use.

2.7.8.2 Two pairs of nuts shall be welded on the side-panel of the housing at a position above the opening. These nuts are intended for use with clamps to secure vertically a 65mm diameter PVC pipe for leading in the overhead temporary wires for tapping of supply from the box. The ends of nuts shall be permanently sealed to prevent rainwater from getting onto the box.

2.7.8.3 The lighting control box front apron shall be provided in one piece minimum height 225mm for easier pulling of the wires.

2.7.9 Earth Leakage Relay

Earth Leakage Relay (ELR) shall be approved type and manufactured to the latest edition of BS 4293.

2.7.10 LCBC

2.7.10.1 The timer shall be replaced with a LCBC and accessories (e.g. door sensors, antennas, etc.) with the cost borne by the Contractor. The Contractor shall inform LTA four (4) months in advance prior to the fabrication of control box to cater for the number of the LCBCs to be installed in new control boxes.

2.7.10.2 The installation of the LCBC shall be securely fastened by suitable stainless steel screws that are not removable from the outside of the panel.

2.7.11 Fuse Carriers and Fuse Bases (incorporated in lighting control box)

2.7.11.1 The HRC fuse carriers and bases shall be moulded from high quality electrical grade thermosetting moulding compounds with high dielectric strength to ensure excellent rigidity and dimensional stability under high temperature conditions.

2.7.11.2 The design of the fuse carrier and base shall be for maximum contact area between the base terminals and carriers. The terminals shall be made of robust extruded non-ferrous conductor.

2.7.11.3 The fuse bases shall have contacts with cable entry holes and cable clamping screws made to the latest edition of BS:88 PART 1: Section 2.1 & Section 2.2.

2.7.12 Electro-Magnetic Contactor

2.7.12.1 The contactor shall be manufactured in accordance with the latest edition of 60947-4 and BS 5424 Part I. This contactor shall be suitable for use in the tropical climate and it is intended to be mounted in an enclosure. They shall be provided with main contacts capable of at least 105 switching operations and at least two auxiliary contacts for remote control (230 Volts, AC). Contactors for lighting control shall be of Utilisation Category AC3, Class 3.

2.7.12.2 The rated operating current shall be 60 Amps when used on 400 Volts, 50 hertz (rated operating voltage and frequency) and for uninterrupted duty.

2.7.12.3 The contactors shall have at least 900 Amps making capacity and 720 Amps breaking capacity to prevent contact welding during switching on and off.

2.7.12.4 The rated operating magnetic coil voltage shall be 230 Volts ±6%, 50 hertz ±1%, single-phase. The coil shall be preferably encapsulated type.

2.7.13 Contactor Enclosure Box

2.7.13.1 The box shall be designed to contain a 60 Amps three-phase contactor. Its size shall be:

LENGTH	WIDTH	DEPTH
190mm - 200mm	190mm - 200mm	130mm - 135mm

2.7.13.2 The box shall be dust-protected and preferably be constructed of thermoplastic self-extinguishable material. The cover of the box shall be transparent.

2.7.13.3 Mounting rails or similar attachments shall be provided on the base of the box for easy mounting of a contactor.

2.7.13.4 The box shall be provided with eight (8) nos. holes on the top side for entry of 16mm^2 single-core and three (3) holes on the bottom side for entry of 35mm^2 single-core (box mounted in a vertical position). 11 nos. of entry seals (grommets) are to be provided for the entry holes.

2.7.14 Modification of existing Lighting Control Box

2.7.14.1 Retrofit of existing lighting control box with new pitched roof.

2.7.14.2 For both retrofitting of existing lighting control box roof and new boxes, the following shall comply:

(a) Proposed new pitched roof design to slope of one side to 30^{o} shall have rounded corners to match existing lighting control boxes. All drilling, punching, cutting, bending and welding parts shall be completed and all burrs removed before the electrostatic powder coating process is applied;

(b) A Degree of Protection of not less than **IP 55** IEC Publication 529: 1989 will be achieved;

(c) The modified roof shall be electrostatically coated with pure polyester powder of thickness between 80 microns and 100 microns. Materials shall be chemically treated before and oven baked after the powder coating process. The powder coating shall be weather resistant;

(d) To ensure ease of fabrication and installation on site, the new pitched roof will feature fully welded side joints (no spot welding);

(e) The material will be 3mm thick, at least aluminum alloy **AA1100**;

(f) Mounting systems on the lighting control box will be on the pre-existing control box roofs secured with external M6 screws that shall be of stainless steel; and

(g) The finishing and colour shall match the existing lighting control box roof or otherwise instructed by LTA.

2.7.15 Gen 2 Lighting Control Box Modification

2.7.15.1 The following items shall be incorporated:

(a) 13A single gang switched socket outlet c/w moulded box;

(b) 2.5mm^2 1-core PVC cable;

(c) 40 Amps 2P 30mA-100mA RCCB;

(d) Three phase 0.3 - 3A / 0.3 sec earth leakage relay complete with ZCT and MCB;

(e) Minimum two (2) earth pits; and

(f) 63A TP contactor.

2.8 Lighting Pole Cut-Out Unit

2.8.1 General

2.8.1.1 The body of the cut-out unit shall be made from material with good insulation properties having a BS 5901 Tracking Index of not less than 500. The material grade specified should also have an operating temperature rating of 55^{o}C and be proven to resist moisture absorption from humid atmospheres. The front cover shall be transparent and provided in two portions to allow the replacement of fuses without exposing the cable terminals. The terminal cover shall carry a warning of "DANGER LIVE TERMINALS" including the symbol of a triangle with a lightning bolt. The insulating terminal cover shall provide a degree of protection of not less than **IP 4X** to the latest BS EN60529 (except for three-phase cut-out unit). The base of the housing shall be opaque and shall be suitable for use in the tropics and of robust construction. It shall be drip-proof and be suitable for installation onto a steel mounting plate within an octagonal street lighting steel pole.

2.8.1.2 The cut-out unit shall be designed and constructed in accordance with the latest edition of BS 7654 or IEC 61439. It shall be designed for ease of cable termination and in addition, screws for the cut-out unit cover should be self-retaining.

2.8.1.3 The minimum clearance and creepage between the different phases shall be at least 6mm.

2.8.1.4 The insulation thickness separating the different phases shall meet impact test and short circuit test requirements in accordance with the latest edition of IEC 61439 or equivalent standard.

2.8.1.5 The cover for the cut-out unit shall be made of material with similar insulation properties and temperature ratings as the material used for the base. The mechanical resistance level of the cut-out unit shall be at least **IK 05**.

2.8.1.6 The cut-out unit shall be supplied complete with armour continuity clamps or similar devices to ensure electrical continuity between the armours of the two (2) - three (3) main cables. The design of clamps or glands shall be such that the cables can be easily installed. The clamps or glands shall be made of brass.

2.8.1.7 For three (3) incoming and / or three (3) outgoing cables, a component base cut-out unit shall be used unless otherwise specified by the Authority. It shall also be used along coastal area or locations where it's prone to lightning activity.

2.8.2 Cable Termination inside a Single-phase Cut-Out Unit

2.8.2.1 The cut-out unit shall be suitable for use in a 230 Volts, single-phase, 50 hertz, 3-wire system.

2.8.2.2 It shall be suitable for terminating two (2) nos. 4mm^2 or 6mm^2 or 10mm^2, 3-core XLPE/SWA/PVC cable manufactured to the latest edition of IEC 60502-1 or equivalent standard.

2.8.2.3 Where tunnel terminals are used the incoming phase and neutral terminals shall have sharply serrated bores to break through any surface oxidisation on the cables and to ensure a low resistance contact.

2.8.2.4 The cut-out unit shall be provided with four (4) termination blocks and six (6) nos. 4mm^2 or 6mm^2 or 10mm^2 copper lugs for the live, neutral and earth conductors.

2.8.2.5 Insulated barriers shall be provided to separate the live and neutral terminals.

2.8.2.6 The cut-out unit shall also be provided with two (2) 2.5mm^2 copper sleeves, three (3) nos. of screws (brass, M12), three (3) nos. of plastic nuts for mounting the cut-out unit onto the baseboard in the pole. Two (2) circular rubber glands shall be provided at entry of the two (2) main 4mm^2 or 6mm^2 or 10mm^2 cables.

2.8.3 Cable Termination inside a Three-phase Cut-Out unit

2.8.3.1 The cut-out unit shall be suitable for use in a 400 Volts, three-phase, 50 hertz, 4-wire system with system neutral solidly earthed.

2.8.3.2 The Degrees of Protection for this unit shall be at least **IP 42**.

2.8.3.3 It shall be suitable for terminating two (2) - three (3) nos. of 16mm^2 4-core XLPE/SWA/PVC cable and two (2) - three (3) nos. 16mm^2 PVC C.P.C. (earth cable) manufactured to the latest edition of IEC 60502-1 or equivalent standard.

2.8.3.4 The cut-out unit shall be provided with termination blocks and 10 nos. 16mm^2 copper lugs for the brown, black and grey phase, neutral and earth conductors. Each termination block must be able to accommodate between two (2) cores - three (3) cores of the XLPE/SWA/PVC cables.

2.8.3.5 Where tunnel terminals are used the incoming phase and neutral terminals shall have sharply serrated bores to break through any surface oxidisation on the cables and to ensure a low resistance contact.

2.8.3.6 Insulated barriers shall be provided to separate the phase terminals.

2.8.3.7 The cut-out unit shall also be provided with two (2) 2.5mm^2 copper sleeves, three (3) nos. of 25mm long screw (brass, M12), three (3) nos. of plastic nuts for mounting the cut-out unit onto the baseboard in the pole and one (1) 140mm cable tie (orange colour). Two (2) - three (3) circular rubber glands are to be provided at entry of the two (2) - three (3) main 16mm^2 cables.

2.8.4 Copper lugs and fuse Unit

2.8.4.1 16mm^2 copper lugs for three-phase system shall be fixed on the respective termination blocks with self-retaining M6 screws before delivery.

2.8.4.2 A fuse unit (suitable for one (1) - four (4) 10 Amps HRC fuse with offset open-ended slot, 2-hole fixing) or other protection devices shall be provided on the fuse cover. Provision for connection of luminaire wire at the fuse, neutral and earth terminations shall also be included. The fuse link shall be fixed and supplied together with the cut-out unit.

2.8.5 Termination Block & Link

The terminal blocks for the termination of the three-phase shall be designed to accommodate links at the cable terminals. The function of these links is to enable the cable cores to be separated during testing, thereby reducing the time taken to isolate the cables. The links shall be pivoted at the outer termination screw.

2.9 Earthing System

2.9.1 General

2.9.1.1 The earthing system shall comply with the latest requirements stated in SS 638: Code of Practice for Electrical installations and SS 551: Code of Practice for Earthing.

2.9.1.2 The earthing system components shall be tested and conformed with the latest IEC EN 62561.

2.9.1.3 The earthing system shall comprise of the earth electrodes, earth continuity conductor (earthing tape or bonding conductors shall be yellow-and-green PVC insulated high conductivity copper) and earth terminals and earth bar.

2.9.1.4 The final arrangement and number of earth pits shall be determined by testing on site before commencement of electrode installation. Each earth bed shall consist of specified number of copper bond steel rod electrodes connected by 16mm^2 yellow-and green PVC cables buried at a depth of at least 500mm below the ground. Each electrode shall be of 16mm diameter, 2 x 1,800mm long spaced at a minimum distance of 6,000mm spacing and driven with steel head and tip and connection clamps. All equipment and accessories shall be of proprietary made.

2.9.1.5 The earth electrode shall be housed with hot-dipped galvanised lid earth pit haunched in concrete and heavy-duty covers. The earth chamber dimension shall be at least 300 mm x 300 mm x 190 mm. The cover shall be flushed to the ground level. A PVC plate engraved with the words “CYCLING PATH LIGHTING. DO NOT REMOVE” or “FOOTPATH LIGHTING. DO NOT REMOVE” or “PUBLIC STREET LIGHTING. DO NOT REMOVE” shall be fixed to each inspection chamber cover. A sample of the chamber shall be submitted to LTA for approval.

2.9.1.6 The inspection chamber shall be filled with “washed” sand to appropriate height and skirting with concrete of at least grade 20 all round with the dimension of 100mm (W) x 50mm (D).

2.9.1.7 The electrodes shall be driven into the ground by a purpose made hammer and the earth pit shall be connected to the earth bar in the control box using 16mm^2 yellow-and-green PVC insulated high conductivity copper cable.

2.9.1.8 The earthing system shall be connected in a ring, continuous throughout its length without joints to the earth bar in the lighting control box.

2.9.1.9 Testing of earth resistance shall be carried out in dry weather conditions. The earthing resistance shall not exceed one (1) ohm.

2.9.1.10 A test report endorsed by the LEW bearing the test result of the earth loop impedance test shall be kept in the lighting control box.

3.0 LED ZEBRA CROSSING FLASHING BEACON LIGHTING SYSTEM

3.1 General

The flashing beacon Technical Specification shall follow those as stated in Street Lighting Specification except those guidelines as stated below.

3.2 Light Emitting Diode (LED) Flashing Beacons

3.2.1 General

(a) The LED flashing beacons for Zebra Crossing Lighting shall have full 360^{o} illumination;

(b) The LED flashing beacons shall be rated minimum **IP 54**;

(c) A sample of LED flashing beacon with specification shall be submitted for approval before installation; and

(d) The terminal block shall be using cable coupler (3-way plug and socket) and shall comply with the latest edition of SS 638.

3.2.2 LED Module

(a) The LED module shall comprise the following:

(i) A LED bulb;

(ii) Failure detection circuit with red indicator LED;

(iii) Flashing system (integrated or remote type); and

(iv) Synchronization system (shall be independent from the light source).

(b) The LED module shall not be operating at more than 10W. The minimum luminance of the flashing beacon at the start of operation shall be at least 360cd/m^2 (measured with the globe installed over it). Should the LEDs malfunction such that the luminance of the flashing beacon (measured with the globe installed over it) fall below 300cd/m^2, a red indicator LED or equivalent indicating mechanism shall light up, providing a signal to maintenance staff that the LED module needs replacement;

(c) The red indicator LED shall be located at the bottom of the LED module. When the red indicator LED is lit, the light shall be visible without having to remove the globe;

(d) The LED module shall have a flashing system that is able to flash 40 - 50 times per minute. The flashing system shall be integrated in the LED module or remotely mounted within the zebra pole;

(e) The flashing system shall allow the beacons to flash in synchronization at each zebra crossing except where the supply is from a different source. The installation shall be restricted to the boundary between the cut-out unit and the LED beacon.

There shall be no need for additional connecting cables between the zebra crossing beacon poles;

(f) The LEDs shall be in the form of a bulb with E27 lamp holder; and

(g) The LEDs used shall be of high output flux density type and with rated life of at least 50,000 burning hours.

3.2.3 A layer of protective lacquer or antioxidant shall be applied over the printed circuit board to prevent oxidation and deterioration of the copper track and solder point under local temperature and humidity conditions.

3.3 Globe

3.3.1 The globe shall be vandal proof, high density, UV stabilised polyethylene or more superior material.

3.3.2 The diameter of the globe shall be 300mm.

3.3.3 The wall thickness of the globe shall be minimum 2mm.

3.3.4 The colour of the globe shall be RAL1023 Traffic yellow or equivalent.

3.3.5 The globe shall be engraved with the year of manufacture near the rim. The numerals shall be 5mm x 20mm.

3.4 Base Connector

3.4.1 The base connector shall be made such that it can fit into the flashing beacon pole of diameter 76mm.

3.4.2 The base connector shall be hot-dipped galvanised and powder-coated RAL 9004 or equivalent.

3.5 Pole Label

3.5.1 Flashing beacon pole shall be labelled with white, retro-reflective, self-adhesive label. The white retro-reflective sheeting shall comply to Type 11 of ASTM D4956 - 11a. The height of the alphabets / numerals shall be 100mm.

3.5.2 The whole piece of label should have a minimum warranty of seven (7) years from the sheeting manufacturer. Quality audit must be performed by the sheeting manufacturer to ensure proper fabrication and conformance to specification.

3.5.3 Each pole label must be silkscreen printed with the Sheeting Manufacturer's initials as well as the year of manufacture on it. The silkscreen printed initials / year of manufacture should not affect the visibility of the label and therefore should be kept at a size lesser than 3mm x 10mm to be printed at the bottom of the alphabets / numerals.

3.5.4 Each pole may require up to three (3) labels. Sample of the label, pole numbering and height and position of the labels shall be submitted for LTA's approval.

3.6 Test and Test Certificates

3.6.1 The LED flashing beacon comprising of the LED module, globe and base connector shall be submitted to a recognised accredited laboratory for the following tests:

(a) Luminance Test: To conduct measurement of the luminance of the LED flashing beacon after 1,000 burning hours; and

(b) Power Consumption Test: To conduct measurement of the power consumed by the LED module.

3.6.2 The manufacturer shall conduct the following batch tests in the factory prior to delivery:

(a) Environmental Test: To verify that the LED flashing beacon can operate reliably under local temperature and humidity conditions; and

(b) Burning Test: To ensure all components in the LED flashing beacon can meet the requirements of the Specification after continuous operation of 1,000 hours.

3.6.3 Manufacturer's batch test reports shall be submitted together with each delivery. Otherwise, the delivery will not be accepted.

3.7 Warranty

3.7.1 The LED flashing beacon manufacturer shall provide a warranty against all defective materials and workmanship for a minimum of ten (10) years after the date of Completion of the Works certified by LTA.

3.7.2 The warranty shall cover the following:

(a) Drop in illuminance of the flashing beacon (measured with the globe installed over it) below 300cd/m^2;

(b) Fault in the failure detection circuit;

(c) Fault in the flashing system;

(d) Error in synchronization;

(e) Failure of LED power supply unit;

(f) Fading of globe colour.

3.8 Crossing Floodlights / Luminaire

The crossing floodlight shall be of post top mounted / with spigot, side mounting and the luminaire used shall be in accordance with the Luminaire Specification, Clause 2.1. It shall complete with LED luminaire of appropriate wattage.

3.9 Poles

3.9.1 Flashing beacon poles shall have a height of 2,500mm above ground level. The poles shall be hot-dipped with tubular galvanised steel. It shall be completed with a hinge base door with a door swing of 180^{o} and with a mounting board.

3.9.2 Each pole shall be painted with one (1) base coat of primer. These include specific formulations of the following types:

(a) Modified acrylic water-borne primers;

(b) Certain water borne self priming finishes; and

(c) Etch primers.

3.9.3 The type of primer used shall be recommended by the pole supplier and it shall be compatible with the finish coats used.

3.9.4 The finish coat is Traffic yellow (RAL 1023) and traffic black (RAL 9017) or equivalent and shall be painted as specified in the Drawings.

4.0 SUBMISSION REQUIREMENTS

4.1 Relocation of existing street lighting pole / zebra crossing flashing beacon pole - Development Building Control (DBC)

(a) The relocation works refer to localize diversion of existing street lighting pole arising from development's external works, changes of entrance access or due to construction of bus shelter, etc.;

(b) The submission for such planning proposal of relocation works request shall be submitted to LTA, DBC (Development Building Control) for approval;

(c) Prior to the relocation of streetlight or zebra crossing flashing beacon, the Qualified Person (QP) is to submit to LTA, DBC for approval with:

(i) Location plan showing the proposed development;

(ii) Part plan showing the affected lighting pole (with the pole id) and new proposed lighting pole position with distance between lighting pole and setback position;

(iii) Information of the affected existing lighting pole includes pole height, arm length, pole type and luminaire type that complied with the guidelines;

(iv) Photographs of affected lighting pole with surrounding landmark and background; and

(v) Lux Simulation sheets that covered the two (2) adjacent lighting pole.

(d) The following Photometric Data relevant to each luminaire type shall also be provided:

(i) Isolux Diagram;

(ii) Utilization Factor Curves;

(iii) Polar Curves;

(iv) Downward Light Output Ratio; and

(v) Downward and Upward Flux Fractions.

4.1.1 Before commencement of site work

4.1.1.1 After obtaining the planning approval from LTA, DBC and before the commencement of site work, QP is to submit to LTA, Traffic & Street Lighting (T&SL) the following at least two (2) weeks in advance:

(a) Original / Certified true copy of the Electrical single line diagram (SLD) endorsed by an Electrical Professional Engineer (PE), where applicable;

(b) Original / Certified true copy of design electrical load calculation sheets endorsed by an Electrical PE, where applicable;

(c) Original / Certified true copy of the pole's concrete foundation design and calculation with Structural / Civil PE endorsement; and

(d) Catalogues of pole, LED luminaire, the luminaire gears, cables, cut-out unit, control box, its accessories and concrete base, HD UPVC pipe, cable warning slab, fuse, earthing accessories, j-bolts, etc. including the Country of Origin as well as respective test and test certificates.

4.1.1.2 The applicant shall apply for permit to carry out the works through the "Permit for Road Occupation Management Portal (LTA.PROMPT) upon receiving "No objection" from LTA, T&SL after the satisfactory acceptance of the above documents.

4.1.1.3 The PE (Civil and Electrical) shall comply with all written law, bylaws, rules, regulations and Code of Practices of any government ministries, statutory boards or other public authorities which are applicable or relevant to the execution of the services.

4.1.1.4 The PE (Civil and Electrical) shall conduct site visits to investigate and ensure design to suit the actual site condition for installation of new poles or relocation of poles, etc..

4.1.1.5 The Electrical PE shall arrange for licensed cable detection worker to carry out detection of underground services prior to commence of works and carry out appropriate protection during the course of works.

4.1.2 Completion of site work

Upon the completion of site work, the QP is to submit to LTA, DBC the following:

(a) Photographs showing the installation work such as excavation work, trench depth, underground pipes laying, poles installation etc.;

(b) Photographs showing the reinstatement work;

(c) As-built drawing; and

(d) Make arrangement with LTA, T&SL for turning on of street lighting inspection.

4.1.3 Defect Liability Period (DLP)

4.1.3.1 The DLP is a warranty period that starts after the completion of street light installation and successful turn-on upon Authority's inspection.

4.1.3.2 For some cases, LTA DBC shall be the initiator to starts the DLP.

4.1.3.3 The developer / contractor shall ensure that the installed streetlights are maintained in a defects-free condition during the DLP. Should there be any emergency repair work, the LTA street lighting term contractor shall assist in replacing any defect parts as the first responder. Any cost incurred shall be borne by the developer / contractor.

4.2 New installation of street lighting / zebra crossing flashing beacon lighting - Building Plan (BP) Approval

(a) Prior to the installation of streetlight or zebra crossing flashing beacon lighting, the QP is to submit to LTA, DBC the following:

(i) Checklist for street lighting design submission (Appendix A);

(ii) Plan showing the proposed development;

(iii) A copy of the approved street layout plan;

(iv) The proposed plan showing:

(1) position of the proposed poles with distance between lighting poles indicated;

(2) proposed underground cable routing; and

(3) proposed lighting control boxes (LCBs) location.

(v) Lux Simulation sheets;

(vi) Original / Certified true copy of the Electrical SLD endorsed by an Electrical PE;

(vii) Original / Certified true copy of design electrical load calculation sheets endorsed by an Electrical PE;

(viii) Original / Certified true copy of the pole's concrete foundation design and calculation with Structural / Civil PE endorsement; and

(ix) Catalogues of pole, LED luminaire, the luminaire gears, cables, cut-out unit, control box, its accessories and concrete base, HD UPVC pipe, cable warning slab, fuse, earthing accessories, j-bolts, etc. including Country of Origin as well as respective test and test certificates.

(b) The following Photometric Data relevant to each luminaire type shall also be provided:

(i) Isolux Diagram;

(ii) Utilization Factor Curves;

(iii) Polar Curves;

(iv) Downward Light Output Ratio; and

(v) Downward and Upward Flux Fractions.

4.2.1 Before commencement of site work

4.2.1.1 The applicant shall apply for permit to carry out the works through the "Permit for Road Occupation Management Portal (LTA.PROMPT) upon receiving "No objection" from LTA, T&SL after the satisfactory acceptance of the above documents.

4.2.1.2 PE (Civil and Electrical) shall endorse all designs and calculations.

4.2.1.3 The PE (Civil and Electrical) shall comply with all written law, bylaws, rules, regulations and Code of Practices of any government ministries, statutory boards or other public authorities which are applicable or relevant to the execution of the services.

4.2.1.4 The PE (Civil and Electrical) shall conduct site visits to investigate and ensure design to suit the actual site condition for installation of new poles, etc.

4.2.1.5 The Electrical PE shall arrange for licensed cable detection worker to carry out detection of underground services prior to commence of works and carry out appropriate protection during the course of works.

4.2.2 Defect Liability Period (DLP)

4.2.2.1 The DLP is a warranty period that starts after the completion of street light installation and successful turn-on upon Authority's inspection.

4.2.2.2 LTA, DBC shall be the initiator to starts the DLP.

4.2.2.3 The developer / contractor shall ensure that the installed streetlights are maintained in a defects-free condition during the DLP. Should there be any emergency repair work, the LTA street lighting term contractor shall assist in replacing any defect parts as the first responder. Any cost incurred shall be borne by the developer / contractor.

5.0 Handing Over of installations to LTA

5.1 For the handing over of installations to LTA, T&SL the Developer shall submit the following in softcopy (except clause 5.1(e)):

(a) As-built layout drawing;

(b) Electrical single-line diagram (SLD);

(c) Electrical test reports;

(d) Operation and Maintenance manuals (only if it is non-standard poles);

(e) 3 sets of lighting pole access door key (only if it is non-standard poles); and

(f) Catalogues of pole, LED luminaire, the luminaire gears, cables, cut-out unit, control box, its accessories and concrete base, HD UPVC pipe, cable warning slab, fuse, earthing accessories, j-bolts, etc. (only if it is non-standard items) including Country of Origin as well as respective test and test certificates.

5.2 Until the installation is satisfactorily taken over by LTA, TSCF, the Electrical QP shall be fully responsible to attend to any breakdown fault, complaints, malfunction and whatsoever that may arise, directly or indirectly which required rectification and restoration to normal working conditions.

5.3 The Electrical QP shall submit a letter of notification of the commissioning of street lighting to LTA, T&SL.

5.4 The billing of electricity consumption shall come under LTA, T&SL only after the road is declared a public street.

5.5 LTA shall take over maintenance of the street lighting upon expiry of one month from the date the road is declared a public street.

APPENDIX A

CHECKLIST FOR STREET LIGHTING DESIGN SUBMISSION

(✓) Tick the appropriate box for all items

Part A: Technical Information

S/n	Standard Requirements	Applicable	Remarks
		Complied with	
1.	Location plan in A1 size is enclosed		
2.	Approved street layout plan in A1 size is enclosed		
3.	Layout diagrams of poles locations, underground cable routing, and lighting control box, in A1 size is indicated and highlighted		
4.	Type of LED luminaire, details of poles e.g. height, hot-dipped galvanised, single / double arm, arm's length, etc. is enclosed		
5.	Catalogues of pole, LED luminaire, the luminaire gears, cables, cut-out unit, control box, its accessories and concrete base, HD UPVC pipe, cable warning slab, fuse, earthing accessories, j-bolts, etc. including manufacturer and / or Country of Origin is enclosed		
6.	Average illuminance (can comply)		
7.	Illuminance Uniformity Ratio can comply		
8.	Original / Certified true copy of the Electrical single line diagram endorsed by an Electrical PE is enclosed		
9.	Electricity supply for street lightings is taken from the proposed LCB		
10.	Source of power supply is indicated in the layout drawings		
11.	Lux simulation, design calculation & isolux diagram is enclosed		
12.	Original / Certified true copy of the pole's concrete foundation design including its calculation endorsed by the Structural / Civil PE		

Note:

Items 1 to 12 are subject to review and approval from Dy. Director, Traffic & Street Lighting (T&SL).

NAME OF QUALIFIED PERSON	SIGNATURE OF QUALIFIED PERSON	DATE

Part B: Particular Information

S/n	Information to be provided
1.	Name of Organisation undertaking the project and Officer-in-charge _____
2.	Total quantity of existing poles to be removed (if applicable) _____
3.	Total quantity of new poles and LED luminaires to be installed under this project _____
4.	Estimated cost per pole, and per LED luminaire for each type (Applicable only for non-standard poles and LED luminaires) _____
5.	Quantity of spares (poles, arms & LED luminaires) that shall be handed over to LTA after DLP for each type (Applicable only for non-standard pole and LED luminaire. Minimum 5% or three poles, arms & LED luminaires (whichever is higher) to be handed over to LTA) _____
6.	Expected project commencement date _____
7.	Expected project end date _____

_____	_____	_____
NAME OF OWNER	SIGNATURE OF OWNER	DATE

Table H (LED - For Cycling Track & Footpath only)
Performance Data of the proposed LED luminaires - S1-S6 (3,000K)

Scenarios	1	2	3	4	5	6
Type of luminaire and LED						
Luminaire model						
No. of LEDs in the luminaire						
No. of LEDs per module						
No. of driver						
Driver - dimmable (Yes/No)						
Warranty period (≥ 10 years)						
HPS equivalent rating (W)	*70w equivalent*					
Proposed LED rating per luminaire (W)						
Total system power (W)	*≤ 16W*					
System power of proposed luminaire (W)						
Initial LED lumen (lm)						
Colour temperature (K)	3,000 +/- 5%					
Efficacy (≥ 100 lm/W)						
Front cover type (Tempered Glass, IK08)						
Maintenance / Light loss factor	0.80					
IP for optical compartment	IP66					
IP for gear compartment	IP66					
Country of manufacture of luminaire						
Country of manufacture of LED						
Description of pole						
Pole height (m)	3.5					
Bracket arm / Spigot (m)	Refer to LTA Street Lighting Installation Guidelines (Drawings) for details					
Pole setback (m)	0	-2	0	-1.8	0	0
Bracket arm / Spigot angle of inclination (degree)	5					
Pole arrangement	Single Sided Left					
Max. spacing between poles (m)						
Description of road						
Type of surface	Asphalt CIE R3 / C2					
Average luminance coefficient (Qo)	0.07					
Width of cycling path and/or footpath (m)	2	1.8	2+1.8	2	1.8	1.8+2
Illuminance						
Average, Eave (lux)						
Minimum, Emin (lux)	3					
Uniformity, Emin/Eave						
Esc(ave)						
Illuminance (after dimming to comply to Clause 2.3 of LTA Street Lighting Installation Guidelines)						
Average, Eave (lux)						
Minimum, Emin (lux)	2					
Uniformity, Emin/Eave						
Esc(ave)						

To be fill-up by Lighting Supplier

Table H (LED - For Cycling Track & Footpath only)
Performance Data of the proposed LED luminaires - S1-S6 (4,000K)

Scenarios	1	2	3	4	5	6
Type of luminaire and LED						
Luminaire model						
No. of LEDs in the luminaire						
No. of LEDs per module						
No. of driver						
Driver - dimmable (Yes/No)						
Warranty period (≥ 10 years)						
HPS equivalent rating (W)	*70w equivalent*					
Proposed LED rating per luminaire (W)						
Total system power (W)	*≤ 16W*					
System power of proposed luminaire (W)						
Initial LED lumen (lm)						
Colour temperature (K)	4,000 +/- 5%					
Efficacy (≥ 100 lm/W)						
Front cover type (Tempered Glass, IK08)						
Maintenance / Light loss factor	0.80					
IP for optical compartment	IP66					
IP for gear compartment	IP66					
Country of manufacture of luminaire						
Country of manufacture of LED						
Description of pole						
Pole height (m)	3.5					
Bracket arm / Spigot (m)	Refer to LTA Street Lighting Installation Guidelines (Drawings) for details					
Pole setback (m)	0	-2	0	-1.8	0	0
Bracket arm / Spigot angle of inclination (degree)	5					
Pole arrangement	Single Sided Left					
Max. spacing between poles (m)						
Description of road						
Type of surface	Asphalt CIE R3/C2					
Average luminance coefficient (Qo)	0.07					
Width of cycling path and/or footpath (m)	2	1.8	2+1.8	2	1.8	1.8+2
Illuminance						
Average, Eave (lux)						
Minimum, Emin (lux)	3					
Uniformity, Emin/Eave						
Esc(ave)						
Illuminance (after dimming to comply to Clause 2.3 of LTA Street Lighting Installation Guidelines)						
Average, Eave (lux)						
Minimum, Emin (lux)	2					
Uniformity, Emin/Eave						
Esc(ave)						

To be fill-up by Lighting Supplier