2. Earth fault protection;
3. Under voltage and over voltage protection;
4. Voltmeter and selector switch;
5. Ammeter and selector switch;
6. Indicating lamps;
7. Digital meter for kW, kVA, kVAR and power factor meter (multi function meter);
8. Power factor control;
9. ACB shunt trip;
10. Auxiliary contacts for remote monitoring via M & E SCADA system.

The total harmonic voltage distortion at each main low voltage switchboards shall not exceed 5%. Devices with local and remote displays for measuring the percentage of total harmonic distortion (THD) in voltage and current shall be provided at each incomer ACB. All distribution panel boards and/or load centres shall be mounted at suitable height, above the finished floor level. An automatic transfer switch shall get operated to transfer the emergency power load (essential load) to the generator in case of normal power supply failure.

5.4.3.5 Lighting System

Generally, all lighting fixtures shall be applied with 240V 1-phase 50Hz power supply. The major lighting source will be fluorescent lamp, energy saving, high efficiency, low loss and high power factor. The colour temperature of the fluorescent lamp shall be 4,000°K and the colour rendering index (CRI) shall be 80 minimum. Lighting fixtures in finished areas (rooms with ceiling such as office, toilet, etc.) shall be recessed type, equipped with anodized aluminium mirror reflector. Lighting fixtures in unfinished areas such as machine/equipment rooms shall be surface mounted type. For high ceiling areas, the high intensity discharge lamp (HID) including metal halide lamp (MH) and high pressure sodium vapour lamp (HPS) shall be provided. For good colour rendering, the MH lamp with minimum 65 CRI shall be applied. The lighting fixtures mounted at 4.00 to 6.00 meters above floor level shall be of low bay type and, at level more than 6.00 meters shall be of high bay type. All Emergency Exit signs (including ITESS and XPESS) and 50% of the Emergency lighting fixtures in Stations and Tunnels (including cross-passages) shall be of self-contained battery powered (by 2 hours battery power packs) type. Uniformity factor of lighting level for all areas shall be no less than 0.7 and Emergency Lighting level in case of Emergency shall not be less than 25-50 Lux (Please also refer the table below under the heading illumination lighting level) when operated through UPS/DG sets and not less than 10 lux level when the emergency lights are operational only on their own two hours self-contained battery power packs.

Where large numbers of lighting fittings are installed, lighting fittings shall be switched in multiple circuits in order to allow management control of lighting levels [nominally 25 -50 Lux (also backed up by UPS and diesel generator), 33% after revenue hours , 66% during non-peak hours, and 100% of output during peak hours], and lighting fittings shall be supplied from separate power circuits in order to avoid the loss of whole illumination while one power circuit is gone. At PSD the illumination level shall be minimum of 250 lux and shall be provided all along the Platform gap/edge as a passenger safety requirement.

All large areas in stations shall be sub-divided so that alternate luminaries are fed and switched on from the circuits of alternate phases to enhance reliability and cater for local system failure. In Tunnel areas including cross passages area alternate luminaires shall be fed from the circuits of alternate phases.

Tunnel lights shall be of IP65 weatherproof type and IK-10 industrial LED type with housing and Fire Resistant low smoke halogen-free type and of non-combustible materials. Emergency Luminaires inside the Launch box (including mid-ventilation shaft, where applicable) shall be automatically controlled by Door Contactor Switch.

The lighting system shall be On/Off to suit the Emergency level (25-50 lux; Please also refer the table below under the heading illumination lighting level), 33%, 66% and 100% as far as practicable by centralized control PC workstation, via lighting control system, in SCR (in Station) combined with timer and photo cell. Self-contained battery power pack unit with 2 hours operation time shall be provided for all emergency exit signs (including ITESS and XPESS) , emergency lighting for tunnels, cross-passages, public corridors, escape routes, exit ways, staff and plant rooms. The control of normal and emergency lighting in the various areas of the station shall be as follows:

Area	Scheme	Control	Monitoring	By
Public	Peak Traffic Hours (100% Task)	ON/OFF	ON/OFF	Controller in Station Control Room – Pass through 2 –wire Remote Control Station in SCR. Auto Switch on in case of Power failure conditions
	Non-Peak Traffic Hours (66% Task)	ON/OFF	ON/OFF	
	After Metro Revenue Hours (33% Task)	ON/OFF	ON/OFF	
	Emergency	ON/OFF	ON/OFF	
Outdoor	Task	ON/OFF	ON/OFF	Photocell/Timer switch via 2-wire Remote Control Station in SCR.
Plant Rooms, Functional Rooms	Task	ON/OFF	ON/OFF	Local Switch. Auto Switch on in case of Power failure conditions
	Emergency	ON/OFF	ON/OFF	
Ventilation Shaft, Under Platform Void Service, Service Duct, Culvert	Task	ON/OFF	ON/OFF	Local Switch
	Emergency	ON/OFF	ON/OFF	Local Switch Auto Switch on in case of Power failure conditions

All lighting switches shall be indicated on the drawings and mounted at 1,350mm above finished floor level unless otherwise specified. In the rooms with ceiling shall be flushed mounted.

Illumination Lighting Level

Illumination lighting level for all spaces shall conform to the codes and standards such as IS, IES, etc. The uniformity factor shall be not less than 0.7 for long corridors, passenger ways. Emergency lighting level shall be not less than 25- 50 lux for public areas, non-public areas , plant rooms, and escape routes . The following illumination criteria shall be followed at various locations:

Areas	Average Normal (Lux)	Minimum Emergency (Lux)
Lift Maintenance Room (if provided)	150-200	25-50
Inert Gas Room	200-250	25-50
Auxiliary Substation(ASS) Room	200-250	25-50
Low Voltage Switch Gear (LVSGR)	200-250	25-50
UPS Room	300	25-50
DG (Fenced Area) or DG room	200-250	25-50
Transformer Room	200-250	25-50
Signalling Equipment Room	300-500	50
Signalling Control Panel Room	300-500	50
Communication Equipment Room	300-500	50
Communication Maintenance Room	300-500	50
Station Control Room	300-500	50
Excess Fare Office	250-300	25-50
Ticket Issuing Window/Ticket Office	250-300	50
Secure Suite (SS)	200	25-50
Ticket Office Store & safe (TOST)	200-250	25-50
AFC Maintenance Room	200-250	25-50
Station Entrances & Passage ways	250	50
Concourse Public area	200-250	50
Security Room	200-300	25-50
Lift Lobby	200-300	50
Toilets	100-150	25-50
Locker Rooms	200-300	25-50
Lunch Room	200-300	25-50
Cleaners Room	150-200	25-50
Refuse Room	100-150	25-50
Store Room	150-200	25-50
PH Toilet	100-150	25-50
Retail/Commercial	200-300	25-50
Parking (where applicable)	100-200	25-50
Link Bridge	200-300	50
Corridor/Passage way	200-300	50
Fire Escape staircase	200-300	50

Areas	Average Normal (Lux)	Minimum Emergency (Lux)
Paid Lobby Area	200-300	50
Unpaid Lobby Area	200-300	50
Platform (General)	200	50
Platform (Edge)	250	50
Tunnel Ventilation room	150-200	25-50
ECS and other plant Rooms	150-200	25-50
Tunnel Area (including cross-passages)	25-50	25-50

5.4.3.5.1 Illuminated Tunnel Evacuation Signage System (ITESS) / Cross –Passage Evacuation Signage System (XPESS)

(i) The ITESS shall provide a series of clear and unambiguous illuminated signs to indicate the direction in which the passengers should move, in the event of passengers' evacuation from tunnel due to emergencies requiring evacuation.

(ii) The XPESS shall provide clear and unambiguous illuminated signs, which shall indicate the location of the cross passage entrances to the passengers'.

(iii) The integrity, including the operation of the ITESS and XPESS shall be capable of being maintained under fire conditions.

(iv) A mock-up for the ITESS and XPESS shall be provided for the Engineer's approval.

(v) Signage – Visibility

- The illumination level and design of the ITESS and XPESS shall be such that when activated, these signs shall capture the attention of the passengers and staff within the tunnel and also of those being evacuated from the train.
- ITESS shall be mounted up to 12m from the Head Wall / Tail Wall (HW/TW) unit and shall be installed at the opposite side of the platform (tunnel lighting/walkway)
- The design of the ITESS shall ensure that each activated directional arrow is uniformly lit and clearly visible from the track at a minimum distance of 48 meters, taking into consideration the ambient light level within the tunnel.

No spill over of lighting to the adjacent inactivated directional arrow within the same housing shall occur.

When in the "OFF" condition, the ITESS signs shall not show any illumination, and shall be a 'secret sign', not visible due to any ambient or tunnel lighting, including that caused by passing trains.

(vi) Housing and Assembly

- The housing and assembly of the two direction sign shall be suitable for tropical tunnel environment and shall be designed to IP65 rating, fire resistant, LSOH, corrosion resistant and able to

1769

operate under fire conditions. The housing shall be stainless steel type.

(vii) Configuration

- The ITESS signs shall be installed at 24 meter intervals (centre to centre).
- The signs shall be installed at each cross passage entrance.
- The luminaries shall be, as far as practicable, "off-the-shelf" type readily available.

(viii) Power Supply , Cabling and Accessories

- The power for the ITESS & XPESS shall be supplied from the Station UPS system and in addition to this, these shall be backed-up by self-contained 2 hours battery power packs.
- The ITESS and XPES shall be from dedicated circuits.
- The cables for the ITESS and XPESS shall be fire resistant, LSOH, armoured, sheathed and rated at 1100V grade.
- All accessories used shall be selected or designed to ensure that the integrity of the ITESS/XPESS system and circuits are maintained under fire conditions and are suitable for tunnel environment with IP65 rating, fire resistant, LSOH.
- Failure of any ITESS /XPESS fitting shall not affect the rest of the fitting in the circuit.

(ix) Control

- The ITESS and XPESS shall be capable of being either remotely activated through M& E SCADA or from a manual control panel located within the Station Control Room SCR. SCR located at each station shall have control over tunnels (both north bound and sound bound tunnels) on both sides of the station .
- A typical drawing indicating the provision of control circuit grouping is included in the tender drawings. Crossovers and tunnel escape shafts i.e. mid ventilation shaft, wherever applicable, shall be included under separate circuit group.
- The manual control panel in the SCR shall include a key lockable selector switch between "NORMAL" and "TESTING"
  - ➢ When set to "NORMAL" – ITESS and XPESS system shall be interlocked and the key can only be removed in this position.
  - ➢ When set to "TESTING" – ITESS and XPESS system interlocking shall get disabled and all the ITESS and XPESS shall be lit up.
- There shall be another set of selector switch on the manual control panel utilizing the same set of key used for the "NORMAL" & "TESTING" switching. The switch shall enable switching between "REMOTE" and "LOCAL" control.
  - ➢ When set to "REMOTE" - the system shall allow full control from the OCC via the M & E SCADA.

- When set to 'LOCAL' - the system shall only be capable of being manually controlled from the SCR. The key can only be removed in this position.

- When the ITESS is activated, whether locally or remotely, the system shall be hardwire interlocked such that only one directional arrow shall be illuminated per sign.
- When XPESS is activated, whether locally or remotely, the system shall be hard wire interlocked such that ITESS will also be switched on. The XPESS on the North Bound and the South Bound tunnels shall also be interlocked.
- Provision shall be made for bypassing the interlocks on both ITESS and XPESS.
- Lamp Test button shall be designed for checking of indicating lamps on the ITESS/XPESS Control Panel.
- Remote M & E SCADA Control

(a) The interface for remote control of ITESS/XPESS at OCC shall be via voltage free contacts to the interface termination board (ITB).

(b) The control circuit grouping shall be co-ordinated with other emergency systems and linked to the ITB such that separate circuit grouping can be individually controlled.

- Local Station Control

(a) The ITESS /XPESS local control switches in the SCR shall be hardwire interlocked for the respective switch positions "Left / Off / Right" of the respective tunnel section concerned such that only one of the three switch positions of a particular bound tunnel can be activated.

(b) There shall be 3 number of illuminated Push Buttons for XPESS along the cross passage on the mimic panel, located in SCR namely XPESS (North bound tunnel), XPESS (South bound tunnel) and Off.

(c) For evacuating from Tunnel to adjoining Station A or B via the XPESS to the South bound tunnel , the XPESS North bound tunnel illuminated push button shall be depressed from the control panel.

5.4.3.5.2 Tunnel Lighting

(i) Tunnel lights shall be of IP65 weatherproof type and IK-10 industrial LED type with housing and Fire Resistant low smoke halogen-free type and of non-combustible materials.

(ii) Tunnel lighting shall be spaced at not more than 15 m to provide with a minimum illumination level of 25-50 lux

(iii) In Tunnel areas including cross passages area alternate luminaires shall be fed from the circuits of alternate phases to enhance reliability and cater for local system failure.

(iv) The tunnel lighting shall be controlled by the following means:

(a) HW/TW (Head Wall/Tail Wall) – 2- position key override switch comprising with pad lockable cover.

(b) Tunnel lighting control panel (TLCP) at SCR

(c) OCC via M & E SCADA

(v) The 2-position key override switch shall have the following selection option:

(a) LOCAL - It will effectively switch "ON" the tunnel lighting

(b) REMOTE - It will switch "OFF" the tunnel lights, which could then be switched "ON" either by SCR or OCC control.

(vi) Control of the tunnel lighting via OCC shall only be possible when TLCP at SCR is set to its "OFF" position.

(vii) The tunnel lighting can only be switched off when all the three means of control are in the off position.

(a) Control at HW/TW

(b) Control at SCR

(c) Control at OCC

(viii) Tunnel lighting connection shall be of plug and socket type.

(ix) By default tunnel lighting shall be in "OFF" mode.

(x) Upon traction power failure, tunnel lighting between the two- (2) stations shall be switched on automatically. .

(xi) All control and monitoring cables shall be provided from Tunnel Lighting DB and terminated into ITB. All contactors and accessories necessary for control and operation of the tunnel lighting system shall be deemed included in thisContract.

(xii) Tunnel lighting control panel (TLCP) shall be provided in the SCR for local control of the tunnel lighting at SCR.

(xiii) A PLC tunnel lighting controller shall be provided in the platform DB rooms (or as required) for local control of the tunnel lighting or interface with the M&E SCADA for remote controlling at SCR/OCC

5.4.3.6 Small power system

Socket outlet shall be installed in all areas with wiring in radial circuit. Socket outlet for plant rooms shall be 2P+G, 240V, 16A & 3P, 415V, 32A universal pin switched type complying with IEC60884-1, installed with robust box, and exposed conduit. Socket outlet for Control Rooms and offices, that need to be good looking, shall be concealed conduit with boxes types. The Socket outlet shall be installed at 30cm height above finished floor level.

The power socket outlets in Tunnel Area including cross passages for maintenance purpose shall be supplied at 32A/63A, 415 volt, 3-phase, 16A, 240 volt, 1-phase 50 Hz. The socket outlets shall be industrial type 3/5 poles with neutral and earth (TP&N) rated IP65.

Weather proof type Socket Outlet, IP54, shall be provided on public corridor and outdoor area at 15m interval. Socket outlet for public corridors, small appliances shall be equipped with Residual Current Device (RCD) or Earth Leakage Circuit Breaker (ELCB) for human protection from electric shock. In public areas, plant rooms and switch rooms they shall be mounted at 350mm above finished floor levels. In control rooms, offices, staff rooms and mess room they shall be mounted 300mm above finished floor level or above furniture height to suit furniture and equipment layouts. Industrial type power receptacle will be provided along with convenient receptacle to be as a typical group in all plant rooms and workshop area, wherever applicable, for maintenance purpose.

The wiring capacity of conduits shall be as per Table of the current edition of the Indian Standards and as specified.

Conduit shall be run neatly on the surface or buried within the carcass of the buildings as indicated in these Specifications. Conduit shall be run at least 0.15 m. clear of plumbing and mechanical services.

Conduit shall be supported at regular intervals not exceeding 2.5 m. on horizontal runs and 1.5 m. on vertical runs.

The length of thread on the ends of the conduit shall be fixed to the structure or the building independently of the conduit.

The length of thread on the ends of the conduit shall suit the length of internal thread in the end of the fitting or accessory. Excess length of thread shall not be permitted.

Sleeves in floor slabs or beams for conduits shall be made of galvanized sheet steel, securely fastened in position. Floor sleeves shall be with their top and set at least 5 cm. above finished floor. Sleeves in beams shall be finished flush with the surface of the beam. Sleeves in telephone and electric rooms shall be filled with approved materials to provide a fire barrier. Both used and unused sleeves shall be filled.

All openings on floors and walls necessary for cable trays and wireways shall be provided by the Contractor unless indicated as being provided by others.

The conduits, cable trays, wireways and termination boxes for the electrical system shall have to be painted strip colour coding at an interval of 1 m along total length of raceways with;

(1)	Normal Power	:	Orange
(2)	Essential Power	:	Yellow
(3)	Control system	:	Blue
(4)	Network system	:	Grey
(5)	Signalling	:	Pink
(6)	Telecom	:	Purple
(7)	AFC	:	Green
(8)	PST	:	Red

4.4.9.6 Testing and Commissioning

Field inspection and testing for conduit, cable tray and wireway installed shall occur more than 1 week before equipment is energized or tested.

Quality Control

All conduit, cabletray and wireway installed shall be of industrial grade quality and the quality control shall be undertaken in accordance with the procedures set out in the Contractor's Quality assurance and Quality management plan.

4.4.10 Luminaires and Associated Equipment

4.4.10.1 General

The Contractor shall Design, supply, install and commission a high efficiency lighting system for all area and buildings of the Underground Station, Tunnel, cross-passages including emergency lighting system. Light fittings for all areas shall be selected to suit various architectural design and finishes and the Contractor shall allow for the design co-ordination process that this shall entail. The light fittings and all associated accessories shall be subject to the Notice of No objection of the Engineer .

The Contractor shall engage a specialist lighting system consultant for carrying out a detailed review of the lighting design proposed by the Contractor in order to meet the following objectives:

(a) State of art, lighting system with modern smart luminaires;

2159

(b) Energy efficiency;

(c) Integration with Architectural design and finishes of stations including signages;

(d) Aesthetic appearance.

Lighting fixtures shall be manufactured locally by approved factory or imported from abroad.

The design of mounting details of the light fitting shall take into consideration the ease of maintenance. Where light fittings are mounted at high levels, the Contractor shall provide suitable means to enable the light fittings to be maintained without the use of portable ladders or other portable equipment with minimum interruption to the railway operation.

The Contractor shall design, supply, install and commission all the light fittings for all areas.

Emergency lighting in the Tunnel, cross-passages, escape corridors and staircases shall be un-switched.

Lighting in public areas shall be controlled via Lighting Control System's Workstation/M&E SCADA at station control room. The circuitry shall be designed such that the lighting could be controlled to achieve 25-50 Lux, 33%, 66% and 100% illumination levels as specified in Outline Design Specifications.

Lighting levels shall be uniformly distributed throughout the whole station, and shall be designed such that glare, dark recesses and areas of poor lighting levels are avoided. Highlight of 2 times the general illumination level shall be provided by down lighting for main entrance, lift front doors, tops and bottoms of stairs.

All offices, plant rooms, workshop, stabling yard/stabling sidings and stores shall have local switches to control the lighting in that area. Where six or more luminaires are provided in a single room, circuits shall be split and the multi-gang switches shall be provided.

The street lighting shall consist of luminaries on galvanized steel pole, for road lighting.

Illumination levels

The illumination levels for various areas shall be as follows:

Areas	Average Normal (Lux)	Minimum Emergency (Lux)
UG Sump Room	150-200	25-50
Lift Maintenance Room	150-200	25-50
Pump Room	150-200	25-50
Inert Gas Room	200-250	25-50
Medium Voltage Switch Gear (MVSGR)	200-250	25-50
Low Voltage Switch Gear (LVSGR)	200-250	25-50
UPS Room	300	25-50
DG (fenced area) or DG Room	200-250	25-50
Transformer Room (ASS Room)	200-250	25-50
Signalling Equipment Room	300-500	50
Signalling Control Panel Room	300-500	50
Communication Equipment Room	300-500	50
Communication Maintenance Room	300-500	50

Areas	Average Normal (Lux)	Minimum Emergency (Lux)
Telecom closet	200	50
Station Control Room	300-500	50
Excess Fare Office	250-300	25-50
Ticket Issuing Window/Ticket Office	250-300	50
Secure Suite (SS)	200	25-50
Ticket Office Store & safe (TOST)	200-250	25-50
AFC Maintenance Room	200-250	25-50
Station Entrances & Passage ways	250	50
Concourse Public area	200-250	50
Security Room	200-300	25-50
Lift Lobby	200-300	50
Toilets	100-150	25-50
Locker Rooms	200-300	25-50
Lunch Room	200-300	25-50
Cleaners Room	150-200	25-50
Refuse Room	100-150	25-50
Store Room	150-200	25-50
PH Toilet	100-150	25-50
Janitors Closet	150-200	25-50
Retail/Commercial	200-300	25-50
Parking	100-200	25-50
Link Bridge	200-300	50
Corridor/Passage way	200-300	50
Fire Escape staircase	200-300	50
Paid Lobby Area	200-300	50
Unpaid Lobby Area	200-300	50
Platform (General)	200	50
Platform (Edge)	250	50
Tunnel Ventilation room	150-200	25-50
ECS and other plant Rooms	150-200	25-50
Tunnel Area (including cross-passages)	25-50	25-50

4.4.10.2 Standard and Reference

The luminaires and associated equipment shall comply with the following codes and standard:

(1)	IEC 60598-1	:	Luminaires – Part 1: General requirements and tests
(2)	IEC 60598-2	:	Luminaires – Part 2: Particular requirements
(3)	IEC 60400	:	Lampholders for tubular fluorescent lamps and starter-holders
(4)	IS 1913	:	General Safety requirements for luminaires
(5)	IS 1777	:	Industrial luminaires with metal reflectors
(6)	IS 3553	:	Specification for Watertight Electric Lighting Fittings
(7)	NFPA	:	National Fire Protection Association

4.4.10.3 Material Description

The luminaires as specified herein comprise of the lighting fixtures, lamp holders, lamps, ballasts, starters, emergency/exit lights and street lighting fixtures.

The Contractor shall provide lighting fixtures completely factory assembled, wires and equipped with necessary sockets, ballasts, wiring, shielding, reflectors, channels, lenses, brackets, fasteners and other parts necessary to complete the fixture installation.

All lighting fixtures, when installed shall be set true and free of light leaks, warps, dents, and other irregularities. The finish of exposed metal parts of lighting fixtures and finish trims of all recessed lighting fixtures shall be as directed/approved by the Engineer.

Each lighting fixture shall have a manufacturer's label affixed to it in a concealed location and shall comply with the requirements of all authorities having jurisdiction.

All luminaries, in general which are suitable for different applications, shall use energy saving T5 type fluorescent lamps. Unless otherwise stated the LV tungsten halogen lamps luminaries shall be supplied complete with built-in set of transformers. .

After the fixtures are completely installed, the wiring system, wiring and fixtures must be tested against grounds and short circuit.

Power for normal lighting shall be obtained from normal supply lighting panels while the power supply for emergency lighting shall be obtained from UPS lighting panels which are backed-up directly by the Emergency Standby Generator power.

All hanger, cables, supports, channels, frames and brackets of all kinds for safely erecting this equipment in place, shall be furnished and erected in place by the Contractor .

The fixtures shall be supported from the building structure and the hangers shall be adjustable in length.

All fluorescent lamp luminaries shall be supplied with low loss control gear and electronic ballast unless otherwise stated.

Lighting fixtures fitted with the high frequency or electronic control gear shall be disconnected before the circuit is tested for insulation resistance.

Louvers or diffusers shall be restrained to prevent them from falling out of the body of the luminaires under normal conditions and when re-lamping. Metal louvers shall be connected to the body of the luminaire or the earth terminal by an insulated flexible copper conductor.

In addition to the primary fixing, all high bay luminaries shall be provided with safety chains to prevent them failing during cleaning or re-lamping.

4.4.10.4 Component

4.4.10.4.1 Lighting Fixtures

(a) Fluorescent Luminaries

(1) The lighting fixture shall be made from high grade cold rolled steel sheet, 0.8mm minimum thickness, and be provided with a lamp compatible with the control gear used. All sheet steel components shall be suitably pre-treated and painted using acrylic polyester or epoxy powders, to prevent corrosion, in white colour or

otherwise as specified by the Engineer .

(2) Sheet metal work shall be free from tool marks and dents, and shall have accurate angles bent as sharp as is compatible with the gauge and materials of the required metal. All intersections and joints shall be formed true, of adequate strength and structural rigidity to prevent any distortion after assembly. Return or clean edges shall be free of all burrs or sharp spots.

(3) Lamp sockets shall conform to IEC standard or equivalent.

(4) Aluminium reflectors and louvers shall be made from high purity aluminium (99.85% minimum) with low or very low iridescence and a total reflection shall be of 87%. The anodic film shall have a minimum thickness of 2.5 microns.

(5) Diffusers shall be made from UV stabilized acrylic or light stabilized polycarbonate, injection moulded or equal and as approved by the Engineer.

(6) The luminaires shall be clearly marked, giving rated voltage method of operation and lamp wattage.

(7) The 90^0C heat resistant with a minimum diameter of $1.5mm^2$ cables shall be used inside the luminaries and shall be neatly secured within the fittings to prevent undue looseness and contact with the ballasts.

(8) Where wiring passes through the edge of any metal section of the fitting, it shall be protected by an endurance tested grommet used in similar installations. All wire connections to terminals shall be of an approved type as approved by the Engineer. All wiring shall be concealed from view when the luminaries are installed.

(9) The housing shall be fabricated so that all electrical components are easily accessible and replaceable without removing fixtures from their mountings, or altering adjacent construction.

(b) Low Voltage Luminaries

(1) Unless otherwise stated luminaries using low voltage tungsten halogen lamps shall be supplied complete with their own step down transformer.

(2) Wire wound transformers shall be rated at 250/11.8V and comply with IEC60742, Class I/Class II and be insulated to IS or other international standards.

(3) Transformers not containing primary fuse protection shall be provided with accessible local protection.

(c) High pressure discharge Luminaries

(1) Circuits using High pressure Sodium lamps or Mercury Lamps shall contain a superimposed pulse igniter with timer. The unit shall ensure that if the lamp fails to ignite the circuit is isolated after a time delay.

(2) Circuits incorporating auxiliary lamps (example tungsten halogen lamp) shall contain a lamp re-ignition monitor for switching the auxiliary lamp on when the discharge lamp has been extinguished and off after it has re-struck and run up.

(3) All luminaries using metal halide lamps shall be fitted with a protective glass covering to prevent the emission of excessive UV radiation.

(4) The floodlight shall be designed for use with a high-pressure sodium lamp and shall be of weather-tight and dust-tight construction. The fixture housing shall be heavy-duty cast aluminium with an aluminium reflector shaped. The reflector finish shall be suitable for operation of high-pressure sodium lamps without any reduction in rated lamp life. The unit shall have a heat and impact resistant lens. Each fixture shall be supplied with stainless steel door hinges and latches and corrosion-resistant captive hardware.

(d) Emergency Lighting and Exit Sign

(1) The addition of conversion kits to luminaires specified elsewhere shall only be

carried out in the factory of either the original luminaire manufacturer or the suppliers of the conversion kit. In either case the supplier of the conversion kit shall inspect and approve the modification work.

(2) Self-contained conversion kit shall contain an emergency lighting module and battery pack.

(3) The Nickel Cadmium battery shall have ample capacity to maintain lamp in the fitting for up to 2 hours after the mains supply fails.

(4) The module shall contain a battery charger with charge indicator, inverter, low battery voltage disconnect circuit and changeover relay.

(5) The Solid State charging system shall be capable of recharging the battery to full capacity in 24 hours after a total discharge of the battery.

(6) An LED charge indicator shall be visible from below. Allowance shall be made to extend the LED circuit and incorporate it into the luminaire body or into the ceiling adjacent to the luminaire using a purpose made ceiling plate.

(7) The internal temperature of the luminaire shall not exceed the battery manufacturer's recommended ambient temperature for their batteries.

(8) Where the ambient temperature of the luminaire exceeds that recommended for the batteries then the batteries shall be mounted externally in a ventilated sheet steel enclosure with a minimum rating of IP 20.

(9) Where remote conversion kits and/or batteries are mounted more than 0.5m from the luminaire, they shall be interconnected using wiring complying with International Standards.

(10) Conversion kits deriving their emergency supply from a central battery shall contain an inverter ballast and changeover relay.

(11) Exit signs shall be manufactured to meet the appropriate requirements of the local regulations, or other International Standard, and shall be operated from a single phase, 240V 50Hz system. The units, when installed, shall be concealed.

(12) Each Exit sign shall be internally illuminated by two separate systems of lighting.

(13) The housing shall be designed to maintain an internal ambient temperature below that of the lowest temperature rating of any piece of equipment installed therein.

(14) The control circuits shall be suitable for mains operation and shall be designed to enable the luminaries to operate exactly like normal conventional luminaries. However, irrespective of the status of the light switch or the controlling contactor, the luminaries shall automatically illuminate or remain illuminated upon mains failure. Upon restoration of the main supply the lamp shall be switched back to mains supply operation and the batteries shall be re-charged again automatically.

(15) Tunnel lights shall be of IP65 weatherproof type and IK-10 industrial LED type with housing and Fire Resistant low smoke halogen-free type and of non-combustible materials.

(16) Tunnel lights shall be spaced at not more than 15 m with a minimum illumination level of 25-50 lux.

(17) In Tunnel areas including cross passages area alternate luminaires shall be fed from the circuits of alternate phases to enhance reliability and cater for local system failure.

(18) Illuminated Tunnel Evacuation Signage System (ITESS) and Cross Passage Evacuation Signage System (XPESS) are to be installed to provide a series of clear and unambiguous illuminated signs to indicate the direction in which the passengers should move, in the event of passengers' evacuation from tunnel due to emergencies requiring evacuation

(19) Tunnel lighting control panel shall be provided in the SCR for local control of the Tunnel lighting at SCR.

(20) Emergency Luminaires inside the Launch box (including mid-ventilation shaft, where applicable) shall be automatically controlled by Door Contactor Switch.

(e) Luminaires and accessories:

The luminaires and accessories shall be as specified and/or of the following types as below

Sl. No.	Room Name	Type of Luminaires
1	Station Control room, Office area, Security room Maintenance room and Staff room.	Fluorescent
2	UPS room, Electrical switch room, Escalator panel room, UG tank & pump room, Signalling equipment room, Communication equipment room and Power supply equipment room.	Fluorescent
3	Toilet, Cleaners room, Station store room	Fluorescent
4	Plant rooms	Fluorescent
5	Staff Store room	Fluorescent
6	Working area	Fluorescent
7	Work Shop Area	Fluorescent/Metal halide
8	Turn back sidings / Stabling Lines	Metal halide
9	Street Light	High Pressure Sodium
10	Public/Passenger Area	As per the recommendation of the design Architect of the Contractor and as approved by the Engineer

4.4.10.4.2 Lamps

(1) Lamps shall be of the number and types as calculated/required to meet the specifications All lamps installed shall be new, and shall operate on completion of the job.

(2) All lamps of the given type shall be supplied by the same manufacturer. And the basic requirements for each lamp shall be as follows :

(a) Fluorescent Lamps

(i) Tubular fluorescent lamps to be provided shall be of energy efficient, high efficacy T-5 type (> 66 lumen/watt for 18 watt lamp, > 88 lumen/watt for 36-58 watt lamp) with Colour Rendering Index(CRI) in excess of 80 and colour temperature of 4000°K (approximately) unless specified otherwise.

(ii) The fluorescent lamp in tubular bulb shall be of a low-pressure mercury discharge, 26mm diameter glass envelop with an electrode sealed into each end and coated with phosphor powder inside. The lamp contacts are mostly of the pin-and-socket type.

(iii) The compact fluorescent lamp shall be of single end glass envelops, and those with no outer envelope (PL-C, PL-S, PL-L), with tri-phosphor powder coated. The type of lamp caps shall be as accepted by the Engineer .

(b) High Pressure Sodium Lamps

2166

(i) Lamps shall be furnished for all High Pressure Sodium (HPS) floodlighting fixture which shall be installed at street level. The unit of luminous intensity shall be the international candle, and the basis of photometric measure for all lamps shall be expressed in rated watts.

(ii) High pressure sodium lamp shall be high efficacy type (> 80 lumen/watt) with Colour Rendering Index, CRI > 25.

(iii) High pressure sodium lamp shall be E27/E40 base, general service, with 24,000hours minimum rated life, and external igniter circuit shall be furnished as required. .

(c) Metal Halide Lamps

(i) Unless otherwise indicated, Metal Hallide Lamps shall be high-pressurized metal halide gas discharge lamps of bulb type.

(ii) Metal halide lamps shall be high efficacy type (> 65-75 lumen/watt) with Colour temperature of 4000°K, CRI >75.

(iii) It shall be internal coated phosphor and equipped with E27 or E40 base, and shall be base-up or base-down type suitable to the usage conditions.

(d) Incandescent Lamps

(i) Incandescent lamps shall be clear bulb standard with wattage as indicated in the drawings and rated voltage not less than 220 volts.

(ii) Unless otherwise specified, incandescent lamps shall be the type of E27 base and manufactured in accordance to the requirements of Local Standards.

(iii) Ballasts

(3) Ballast for tubular fluorescent lamp

(a) Electronic ballasts shall be used for all tubular fluorescent lamps.

(b) The electronic ballasts shall comply with the following data:

(i) Input Voltage 180 - 270 V, 50 Hz with a constant lumen output and wattage for variation of 190 – 254 V.

(ii) Conforming to IS or IEC standard with test certificates

(iii) Power factor > 0.95

(iv) Total harmonic distortion of input current (THDI) < 5% and conforming to IEC 61000-3-2

(v) Lamp current crest factor < 1.7 conforming to IEC 60929

(vi) Ballast lumen factor > 94 % conforming to IEC 60081

(vii)EMI, EMC, RFI Suppression conforming to IEC 60929

(4) Ballast for compact fluorescent lamp

(a) Ballasts for compact fluorescent lamps shall be low watt loss ballasts conforming to IS and shall be equipped with suitable size of capacitor to improve the power factor of not less than 0.9.

(5) Ballast for high intensity discharge (HID) lamp

(a) Ballasts for high intensity discharge (HID) lamps shall be high power factor or low power factor with dry type capacitor to improve power factor up to 0.9.

(b) The ballast housing shall be of die-cast aluminium, finished in epoxy enamel to suit to the weatherproof protection and shall contain all the electrical control gear including the choke, power factor correction capacitor and igniter of rating compatible with the lamp wattage.

4.4.10.5 Product Handling

The lighting fixtures, components and assemblies shall be delivered in fully sealed protective cartons and identified as to the contents. The fixtures shall be protected from

damage from any source. Each lighting fixture shall be sealed at the bottom with easily removable protective plastic to keep dust out during construction.

Each lighting fixture with a ballast shall have the ballast pre-mounted, pre-wired, pre-tailed and factory tested prior to packaging.

Each lighting fixture shall be packaged with complete instructions and illustrations indicating installation method.

The materials shall be stored in accordance with the manufacturer's instructions, properly protected from weather and construction activities.

Handling shall be in a manner to prevent damage to the finished surfaces.

4.4.10.6 Mock-up

If requested mock-up installation shall be provided for review and approval by the Engineer . The mock-up shall simulate lighting system conditions as specified..

For each substitution item which is not specified mock-up installation shall be provided, if desired by the Engineer at no additional cost to the Employer .

4.4.10.7 Installation

Lighting fixtures shall be installed as per the calculations carried out complying to the Specification herein and as approved by the Engineer, and also to the installation instructions of the manufacturer.

The Contractor shall fully coordinate with the other contractors/sub-contractors in planning and execution of installation to ensure that the fixtures furnished are compatible with the ceiling suspension system being installed and not to cause any damage or deflection to the works of any Project Contractor.

If the lighting fixtures installed by the Contractor cause any damages or deflections to the works of other Contractors, such affected works shall be replaced by the new ones by the Contractor at his own cost/expenses.

The lighting fixtures shall be installed so as to fully effect the light distribution.

Final connections to luminaries in areas where a suspended ceiling is provided shall be in a flexible conduit system.

4.4.10.8 Testing and Commissioning

The lighting system shall be checked at night to ensure that illumination levels as specified have been achieved.

The luminaires and control cables shall be meggered phase-to-phase and phase-to-ground.

The performance of the luminaries and associated equipment shall be tested by switching-on all luminaries in a period of 24 hours, together with measuring of the illumination levels which shall not deviate from the specified levels.

Quality Control

All luminaires and associated equipment installed shall be of industrial grade quality and the quality control shall be undertaken in accordance with the procedures set out in the Contractor's Quality assurance and Quality management plan.

4.4.11 SWITCH AND SOCKET OUTLET

4.4.11.1 General

The Contractor shall Design, supply and install the switch and socket outlet as described and specified herein.

4.4.11.2 Standard and Reference

The switches and socket outlets shall comply with the following code and standard:

(1) IEC 60529 : Degree of protection provided by enclosures (IP Code)

(2) IEC 60309 : Plugs, socket-outlets and couplers for industrial purposes -