

Commuter Facilities Design Requirements

CONTENTS

Title	Rev.	Date
4.1 Commuter Facilities Architectural Design Requirements	A3	June 15
4.2 Commuter Facilities M&E Design Requirements	A2	May 13
4.3 Architectural Checklist For Bus Interchange	A2	May 13

Attached Drawings:

Bus Interchange

L/CFADC/AR/BI/0001-0014

Commuter Facilities Architectural Design Requirements

CONTENTS

1	INTRODUCTION	2
2	BUS INTERCHANGE/ TERMINAL	3
2.1	General	3
2.1.1	Overview	3
2.1.2	Statutory Requirements and LTA Requirements/ Guidelines	3
2.1.3	Studies and Submissions	3
2.1.4	Design Principles and Considerations	3
2.2	Bus Park Area	4
2.2.1	Overview	4
2.2.2	Bus Interchange Simulation Study and Bus Trials	4
2.2.3	Bus Ingress & Egress	5
2.2.4	Bus Parking Lots	5
2.2.5	Driveway	6
2.2.6	Boarding/ Alighting Berths	6
2.2.7	Safety Provisions	6
2.2.8	Design and Finishes	7
2.3	Concourse Area	7
2.3.1	Overview	7
2.3.2	Commuter Accessibility	7
2.3.3	Air-conditioned Bus Interchange	7
2.3.3.1	Walls, Doors and Shutters	7
2.3.3.2	Finishes	8
2.3.4	Non air-conditioned Bus Interchange	8
2.3.4.1	Roof	8
2.3.4.2	Finishes	8
2.3.5	Queue Rails and Boarding/ Alighting Berths	8
2.3.6	Seating Benches	9
2.3.7	Information Panel Boards	9
2.4	Offices and Other Facilities	9
2.4.1	Overview	9
2.4.2	Minimum Size of Offices and Other Facilities	9
2.4.3	Passenger Service Offices	10
2.4.4	Staff Lounge cum Briefing Room	11
2.4.5	Ticket Office	11
2.4.6	Add Value Machine Room	11
2.4.7	Commercial Space	11
2.4.8	Canteen, Kitchen and Rodent-Free Store	11
2.4.9	Server Room	12
2.4.10	Staff and Public Toilet Facilities	12
2.4.11	Bin Centre/ Point and Electrical Substation (Outside Concourse)	12
2.4.12	Bicycle Parking Racks (Outside Concourse)	12
2.4.13	First Aid Room cum Nursing Room	12
2.4.14	Special Purpose Room	12
3	BUS BAYS	13
4	SHELTERS	14
5	PEDESTRIAN OVERHEAD BRIDGE AND PEDESTRIAN UNDERPASS	15

INTRODUCTION

This document outlines the design requirements applicable to bus interchange architectural works. It shall be incorporated along with Sections 2 of the ADC, the relevant CF Checklists, CF E&M Design Requirements, Infrastructure Design Criteria (IDC) and any site specific design constraints to form part of the design brief for a particular project.

1	BUS INTERCHANGE/ TERMINAL
----------	----------------------------------

1.1 General**1.1.1 Overview**

- (a) References shall be made to Drawings L/CFADC/AR/BI/0001-0013 when using this document.
- (b) This document shall apply to all temporary and permanent bus interchanges and bus terminals (collectively named as bus interchange), unless otherwise exempted, with the written approval from LTA.
- (c) An integrated bus interchange is one that is built as an integral part of a larger development.
- (d) A standalone bus interchange is one that is not enclosed, with natural ventilation for the concourse and bus park area.

1.1.2 Statutory Requirements and LTA Requirements/ Guidelines

- (a) Internal and external road elements, including but not limited to, traffic signs, road markings, road humps, thermoplastic markings, signalisation, pedestrian crossings, vehicular impact guardrails, impact bollards, etc shall comply with the latest LTA Standard Details of Road Elements (SDRE) requirements.
- (b) Comprehensive Public Transit Signage System plan, within the bus interchange and its vicinity including the new development, shall be developed, designed and provided in accordance with LTA Signage Design Guideline Manual, Tender Conditions and Reference Manual. The provision, layout, location and detailed design of the signage shall be carried out in consultation with LTA.
- (c) For bus interchange which is in the vicinity of residential housing, noise mitigation measures shall be provided, unless otherwise stated.
- (d) In addition to NParks' green buffer requirement, additional landscaping in and around the bus interchange shall be provided, unless otherwise stated.

1.1.3 Studies and Submissions

- (a) The following studies and reviews shall be carried out and submitted by a specialist/ traffic consultant/ qualified persons to the Authority for approval prior to the finalisation of the bus interchange design and layout:
 - i. Traffic Impact Assessment (TIA), unless otherwise specified by the Authority;
 - ii. Traffic Scheme/ Plan, mandatory for all bus interchanges;
 - iii. Security Consultancy Study, for bus interchange classified as National Critical Infrastructure or Key Installation if required by the Authority;
 - iv. Acoustic Study, mandatory for integrated bus interchange;
 - v. Bus Interchange Simulation Study, mandatory for all bus interchanges;
 - vi. Project Safety Review PSR (Roads) by a qualified independent safety reviewer, mandatory for all bus interchanges;
 - vii. All mechanical and electrical system studies as required under ADC Section 4.2. e.g. Lighting Study, Computational Fluid Dynamics (CFD) Study, Environmental Impact Assessment (EIA) study, and
 - viii. Pedestrian Simulation Study, as required under ADC Section 2.
- (b) The recommendations of the above studies shall be incorporated in the bus interchange design and mitigation provisions shall be catered for prior to the construction of the bus interchange.

1.1.4 Design Principles and Considerations

- (a) All design principles and requirements outlined in all other relevant sections of the ADC shall be complied. Specifically;
 - i. Interfacing development requirements in ADC Section 2 – Chapter 10,
 - ii. Security requirements in ADC Section 2 – Chapter 14

- iii. Ease of maintenance requirements in ADC Section 2 – Chapter 16,
- iv. Mechanical and electrical system requirements in ADC Section 4.2
- v. Commuter facility requirements across ADC sections 4.3 to 4.9.
- (b) The bus interchange shall be designed with the following principles in mind:
 - i. Ease of use by commuters, i.e. minimise transfer walking distance, ensure comfortable, safe and secure environment, ease of way finding, etc; and
 - ii. Cost and operational efficiency of bus interchange, i.e. ensure ease of operation and maintenance, reduce recurrent costs, provide safe and efficient layout, promote staff welfare, etc.
 - iii. Natural lighting shall be brought into public spaces where possible

1.2 Bus Park Area

1.2.1 Overview

- (a) The bus park area shall include all the alighting berths, boarding berths, parking lots, circulation driveway, ingresses, egresses, etc.
- (b) The bus park area shall be designed to be naturally ventilated unless otherwise agreed by the Authority.
- (c) The bus park area shall be designed such that buses need not reverse at any time. In the event that there are serious space constraints, which the designer shall demonstrate that all options are exhausted, only 12m standard buses are allowed to reverse for the design of the driveway and bus parking area. For such cases, sufficient and satisfactory mitigating safety measures (e.g. convex mirrors, reverse sensors) shall be provided. 18m articulated buses shall not reverse within bus interchange for safety reasons.
- (d) The design shall be such that passenger loaded buses need not travel in the driveway where buses are reversing. If unavoidable and upon approval by the Authority, a separate 3.7m lane shall be provided next to the driveway where buses are reversing.
- (e) The bus park area shall be designed with minimal structural columns, unnecessary structures, kerbs or other building elements so as to minimise visual obstruction to the bus drivers and improve the efficiency and safety of bus circulation.
- (f) There shall be no pedestrian routes within the bus parking and bus circulation areas of the bus interchange.
- (g) A minimum clear height of 5.4m, measured from the road level to the underside of all structures or services (e.g. M&E), is required.
- (h) The lateral clearance between the outer edge of the road kerb and any element shall be minimum 0.6m. Bus park area shall be designed with additional clearance taking into considerations the low bus overhangs for wheelchair accessible buses.
- (i) Bus interchange floor shall be designed and treated to minimise vibration impact to the adjoining occupancies caused by the buses travelling at the speed of 30km/h. The assessment of building vibration with respect to human response in adjoining occupancies shall be evaluated in accordance with BS 6472-1: 2008. The vibration dose value predicted shall meet the range with low probability of adverse comments in accordance with Table 1 in BS 6472 for the respective occupied space in the building.
- (j) The structural elements within the bus interchange shall be designed for vehicular impact load and installed with protection bumper. Otherwise, vehicle impact guardrails or bollards shall be installed.
- (k) For proper water drainage, the bus driveway shall be designed with proper run-off and drainage at the perimeter. Catch basin drainage for water catchment shall be provided on the driveway where all boarding and alighting berths are positioned [for details refer to SDRE].
- (l) The platform level of the bus park area shall be higher than the surrounding roads.
- (m) Traffic schemes/ plans shall be provided covering the entire bus park area and peripheral access junctions.

1.2.2 Bus Interchange Simulation Study and Bus Trials

- (a) A Bus Interchange Simulation Study (e.g. swept path/ auto turn analysis) shall be carried out covering the entire bus park area and submitted by an independent specialist/ traffic consultant to the Authority for approval prior to the finalisation of the bus interchange design and layout.
- (b) The scenarios of this study shall include the worst case scenario within the bus interchange, with fully parked buses, fully occupied berths, more than 1 bus waiting to exit, bus overtaking, etc. Parameters of the study, methodology, analysis of the full cycle of the bus movement from the bus entrance into the bus interchange to its exit, and softcopies shall be shared with the Authority and the operators.
- (c) This study shall verify and ensure that the bus circulation, parking, berthing, etc within the bus interchange are safe and efficient for operation.
- (d) This study shall verify and ensure that all berths can allow berthing of wheelchair accessible buses with easy accessibility for passenger-in-wheelchair. The study shall demonstrate that the bus can align parallel and as close to the berth kerb as possible.
- (e) In addition to this study, bus trials on site shall be carried out so as to satisfy the Authority and the operators that the above requirements have been met.

1.2.3 Bus Ingress & Egress

- (a) The number of bus ingresses/ egresses, their nature (separate or combined) and junction arrangement (i.e. full movement signalised junction or limited movement) shall be provided as advised by the Authority. The bus ingresses/ egresses shall have priority over other development accesses, lay-bys, etc.
- (b) Chain gates or barriers shall be provided at the ingresses and egresses. The gates or barriers shall not impede the bus operations and pedestrian flow. To prevent jaywalking, perimeter fencing shall be provided along the perimeter of the bus park.
- (c) Where the pedestrian needs to traverse the ingresses or egresses, signalised pedestrian crossing, overhead or underground pass shall be provided.
- (d) There shall be no obstruction to sight at all the ingresses and egresses. Bus Drivers shall have a clear view of the main road traffic prior to exiting from the bus interchange driveway onto the main road. Minimum clear sight distance shall be provided in accordance with the LTA Civil Design Criteria.
- (e) Double-sided road signs “Buses To Look Out For pedestrians” shall be provided at both sides of all the ingresses and egresses.
- (f) “No Entry except Authorised Vehicles” signs shall be provided at both sides of all the ingresses and egresses.
- (g) Chevron markings on the driveway and road shall be provided at the ingresses and egresses to guide and prevent buses from coming too close to the kerbs.
- (h) Double zigzag lines outside the ingresses and egresses shall be provided.
- (i) The width of the ingresses and egresses shall be minimum 8m for single-direction and minimum 10m for dual-direction, subject to the Bus Interchange Simulation Study.

1.2.4 Bus Parking Lots

- (a) The number of bus parking lots provision shall be 3 parking lots per bus service.
- (b) The parking lot dimensions shall be as follow:

Type of Parking Lot	Overall Width (m)	Overall Length (m)	Equidistance of parallel lots
12m Standard	3.5	12.7	4m apart
18m Articulated	3.5	18.2	6m apart

- (c) All bus parking lots shall fully accommodate standard 12m bus. Numbers of lots accommodating 18m articulated buses to be confirmed by the Authority.
- (d) Bus parking lots shall be demarcated with 100mm wide thermoplastic paint marking. Lots markings shall be yellow or other colours as prescribed by the Authority. For the paint marking, refer to Drawing ref. L/CFADC/AR/BI/0003.
- (e) Bus park wheel stoppers and humps shall be provided for all bus parking lots. They shall be cast in-situ together with the bus park area with proper reinforcement bars/ bolts to the ground. For details of bus park wheel stoppers, refer to Drawing ref. L/CFADC/AR/BI/0003.

1.2.5 Driveway

- (a) The minimum clear width of the driveway shall be as follows:

Type of Driveway	Minimum Clear Width (m)
Saw-tooth Bus Park with driveway on 1 side/ One-directional	12
Saw-tooth Bus Park with driveway on both sides/ Two directional	14
End-on Bus Park with driveway on 1 side / One directional	18
End-on Bus Park with driveway on both sides / Two directional	21

- (b) Kerb height for driveway and berths shall be 150 mm with black/ white strip painting.
- (c) Kerb height at front of end-on-berth parking lots shall be 120mm with black/ white strip painting.
- (d) Driveway ramp gradient shall not be steeper than 1:20.
- (e) In the event that an up-ramp and a down-ramp are needed, the design shall cater and ensure that the point of apex of the ramps clears the bus undercarriage, and front and rear overhangs of the bus. Otherwise, a flat area shall be provided for at least an 18m articulated bus.
- (f) Proper footpaths and pedestrian crossings shall be provided for bus drivers/ operations and maintenance staff.
- (g) Adequate “No Walking Within Bus Park” signs shall be provided (refer to LTA Signage Reference Manual). The signs and location shall be proposed for the Authority’s approval.

1.2.6 Boarding/ Alighting Berths

- (a) The bus interchange shall be designed to cater for the expected number of bus services as prescribed by the Authority.
- (b) For saw-tooth design, the arrangement of the berths shall be in a clockwise manner, starting with alighting berths followed by boarding berths.
- (c) Large, visible and reflective berth number plates outside the concourse shall be provided. The numbering system shall be in clockwise manner, starting with A1 for alighting berth one, B1 for boarding berth one and so on so forth.
- (d) The type of berths and number of bus services shall be as follow:

Saw-tooth Boarding	3 bus services per berth
End-on Boarding and Alighting	3 berths per service
Straight Alighting	6 bus services per berth

- (e) All boarding and alighting berths shall fully accommodate standard 12m bus. Number and allocation of berths accommodating 18m articulated buses to be confirmed by the Authority.
- (f) For saw-tooth boarding berths, the angle of approach shall be 10 degrees to the berths. The length of saw-tooth boarding berths shall be 20m for 12m standard buses. For details, refer to Drawing ref. L/CFADC/AR/BI/0012.
- (g) The first alighting berth after the ingress and the last saw-tooth boarding berth before the egress shall be at least of a straight line distance of 12m.
- (h) At the L-shape bend, the berth after the bend shall have a clear distance of 15m from the last berth (or less depending on Bus Interchange Simulation Study) before the bend.
- (i) For end-on berths, the boarding and alighting ‘tongue’ shall be minimum clear width 1.5m, measured from the road kerb to the outer edge of any railing or obstruction, and in compliance to the requirements of the Code on Accessibility in Buildings. Safety guide stainless steel railings shall be provided along the ‘tongue’. Please refer to Drawing L/CFADC/AR/BI/0001.

1.2.7 Safety Provisions

- (a) Retro reflective sheet shall be provided on the surface of walls, columns, bollards or any other vertical elements.
- (b) Large (not less than 1m diameter/ length) convex mirrors, cylindrical convex mirrors, reverse sensor with warning lights, whichever appropriate, shall be provided, where there are blind spots and visual obstruction.
- (c) There shall be a clear segregation between the pedestrian and bus circulation.

- (d) Vehicle impact guardrail shall be provided for hose reels, hydrants, lamp posts, M&E ducting etc.
- (e) Depending on the types of bus interchange, safety bollards or security bollards shall be installed along the edge of concourse next to the bus park area.

1.2.8 Design and Finishes

- (a) The bus park shall be designed in accordance to latest LTA SDRE requirements and LTA Materials and Workmanship (M&W) Specifications for Roadworks Chapter 10.
- (b) For temporary bus interchange (less than 5 years use), the bus park area, including the access junctions, shall at least be made of rigid pavement. Refer to Standard Details of Road Elements (SDRE) for details.
- (c) For permanent bus interchange, the bus park area, including the access junctions, shall be made of semi-rigid pavement system. For details refer to LTA's Civil Material and Workmanship Specification or Project Specifications.
- (d) The design and colour of the bus park shall be designed with contrast such that the traffic markings are visible.

1.3 Concourse Area

1.3.1 Overview

- (a) The concourse area shall include all the alighting, boarding berths, offices, other facilities, etc as stated in this document.
- (b) A minimum clear width, free from all encumbrances (including queue rails), shall be provided along the concourse based on the following:

No. of Bus Services (n)	$n < 10$	$10 \leq n \leq 20$	>20
Minimum clear width (m)	6	8	10

- (c) The concourse shall be designed with minimal structural columns within the concourse area, entrances/ exits and doors.
- (d) The location and layout of the concourse shall be planned and designed such that the transfer between MRT, bus interchange and bus stops shall be direct and shortest. In addition, the connectivity between these transport nodes, development and commuter facilities (e.g. taxi stand, pick-up/ drop-off bays) shall be sheltered.
- (e) There shall be minimum 3m clear height to the underside of the ceiling.

1.3.2 Commuter Accessibility

- (a) The number and width of pedestrian entrances/ exits and sheltered linkways from the concourse to nearby MRT station, bus stops, commuter facilities and developments prescribed by the Authority shall be a minimum and shall be increased if needed as determined by any Pedestrian Simulation.

1.3.3 Air-conditioned Bus Interchange

- (a) The concourse shall be air-conditioned.
- (b) Where escalators are linked to the concourse, sufficient holding area, with a minimum of 6m distance from the escalator landing comb plates, shall be required. Staircase next to the escalators shall be provided, unless otherwise exempted by the Authority.

1.3.3.1 Walls, Doors and Shutters

- (a) The segregation wall between the concourse and the bus park area shall be 1m height topped with laminated glass panels to the ceiling and then fully enclosed above the ceiling.

- (b) The segregation wall between the concourse and other development shall be a physically opaque wall, unless prior approval is obtained from the Authority.
- (c) All accesses from the Bus Interchange into any development or vice versa, shall be provided with security shutters.
- (d) All entrances leading to outside road (excluding development), boarding and alighting berths shall be equipped with automated screen doors (ASD) with air curtains. These doors shall be heavy duty, tempered laminated glass and equipped with auto lock mechanism when they are switched off after operational hours. The ASD shall be designed to be switched off locally at individual screen doors and alternative remote access from the Passenger Service Office 1.
- (e) There shall be two sliding ASD for each boarding berth. Motion detector sensors on the interior side of the concourse and loop detector sensors on the berth driveways shall be provided to activate the ASD when a bus arrives. For alighting berth ASD, motion detector sensors shall be provided on the exterior side of the concourse area. For end-on berths, motion detector sensors shall be provided on both sides of the ASD.
- (f) Hands-off signs shall be provided at the side of each ASD. Refer to the LTA Signage Reference Manual for the sign details.
- (g) In addition to ASD, manual glass swing doors to the driveway shall be provided for every two berths. These doors shall be made of heavy duty tempered laminated glass.
- (h) All doors shall also be manually lockable.
- (i) Shutter bulk heads and ASD guide rails at the boarding and alighting berths shall be located within the bus park area or enclosed within the ceiling.

1.3.3.2 Finishes

- (a) For walls, cladding finishes shall be provided. For floor, darker shades of tiles shall be provided. Slip resistance shall be in accordance to Section 2 of the ADC - Chapter 3

1.3.4 Non air-conditioned Bus Interchange

- (a) The concourse of a non air-conditioned bus interchange shall be designed to be naturally ventilated. In addition, there shall be provision of industrial type oscillating fans at the concourse area.

1.3.4.1 Roof

- (a) The design of the roof shall cover the entire concourse. In addition, the design of the roof shall cover the boarding and alighting berths driveway area, such that the entire bus, including double-decked bus and 18m articulated bus, is fully sheltered from the rain.
- (b) With the high roof, the design of the roof overhang, louvre/ screen shall ensure no rain pelting into the concourse.

1.3.4.2 Finishes

- (a) For walls, it shall be weatherproof external grade anti fungal paint. For floor, it shall be granolithic.

1.3.5 Queue Rails and Boarding/ Alighting Berths

- (a) Queue rails shall be provided at each boarding berth. Please refer to Drawing L/CFADC/AR/BI/0012 for details of the queue rails.
- (b) The minimum clear width for all queuing areas shall be 700mm and shall be measured between the outer edge of any element including queue rails, signage posts and bum rests.
- (c) The queue rails with bum-rests shall be stainless steel grade 304, hairline finish.
- (d) For all queue rails, overhead stainless steel frame with signage plates for berth number and bus service numbers shall be provided. The berth numbering system shall be in clockwise manner, starting with A1 for alighting berth one, B1 for boarding berth one and so on so forth.
- (e) At the side of all queue rails, signage plates for bus service numbers shall be provided.

- (f) The design of queue rails shall cater for sufficient waiting space for passengers-in-wheelchair which shall be demarcated on the ground with blue-coloured tiles. Pictogram signage shall be erected.
- (g) 600mm wide yellow tactile tiles shall be set at 0.6m away from driveway kerb perpendicular to commuters' flow. Please refer to Drawing ref. L/CFADC/AR/BI/0012.

1.3.6 Seating Benches

- (a) One set of 4-seater benches with armrests shall be provided per boarding berth, with a minimum of six benches.
- (b) The benches shall be stainless steel grade 304, hairline finish and bolted to the ground.
- (c) The location and type/ design of the benches shall be proposed for the Authority's approval.

1.3.7 Information Panel Boards

- (a) Information panel board with locks shall be provided. Refer to the LTA Signage Reference Manual.
- (b) The number of board sets shall be provided based on the following:

No. of Bus Services (n)	$n < 10$	$10 \leq n \leq 20$	>20
Number of Board Set	2	3	4
- (c) Each set shall have 4 glass panels, and may be single or double sided, depending on its location in the concourse, to be confirmed with the Authority.
- (d) The frame of the board shall be aluminium and bolted on ground or wall mounted.
- (e) The location of the boards shall be on one side of the concourse and not impede commuter flow. The location and type/ design of the board set shall be proposed for the Authority's approval.

1.4 Offices and Other Facilities

1.4.1 Overview

- (a) The offices and all facilities stated here shall be included in the concourse, unless otherwise stated.
- (b) All other M&E rooms and facilities needed for the functioning of the bus interchange (e.g. AHU, chiller plant, switch room, MDF, generator rooms) shall be in the concourse area.
- (c) Signage for all offices and other facilities shall be provided.
- (d) The Passenger Service Office 1, Administration Office, Manager Room and Server Room, shall be designed to be contiguous. The Server Room shall be adjacent to Passenger Service Office 1. These, together with the Passenger Service Office 2, Ticket Office and Add Value Machine Room, which are adjacent to each other, shall be centrally located in the concourse.
- (e) All doors and windows shall be lockable.
- (f) The interior finish of all toilets, kitchens and canteen shall as a minimum be; tiled floor & walls and moisture resistant demountable suspended ceiling unless otherwise stated. Slip resistance shall be in accordance to SS 485..
- (g) The interior finish of all offices and other facilities below shall as a minimum be; tiled floor, plastered and painted wall and demountable suspended ceiling unless otherwise stated.
- (h) Electrical substation and any other M&E rooms not listed shall as a minimum be; Reinforced Concrete floor slab with screed and hardener, plastered and painted wall and ceiling.
- (i) Type and specifications of all materials including type and application of skirting shall be subject to confirmation and approval by the Authority.

1.4.2 Minimum Size of Offices and Other Facilities

No. of Bus Services (n)	$n < 10$	$10 \leq n \leq 20$	>20
Passenger Service Office 1 (sqm)	12	14	18

No. of Bus Services (n)			n < 10	10 ≤ n ≤ 20	>20
			(Frontage of 1 glass panels of width 2.2m)	(Frontage of 2 glass panels of width 1.4m each)	(Frontage of 3 glass panels of width 1.4m each)
Passenger Service Office 2 (sqm)			12 (Frontage of 1 glass panel of width 2.2m)		
Administrative Office (sqm)			20	28	36
Manager Room, adjacent to Administrative Office (sqm)			8		
Staff Lounge cum Briefing Room (sqm)			55	75	100
Staff Toilets, adjacent to Staff Lounge	Male	Cubicle	1 standard and 1 ambulant	2 standard and 1 ambulant	
		Wash Basin	2	2	
		Urinal	2	3	
	Female	Cubicle	1 ambulant	1 standard and 1 ambulant	
		Wash Basin	2		
Server Room, adjacent to Passenger Service Office 1 (sqm)			7.5		
Ticket Office (sqm)			9 (Frontage of 1 glass panel of width 2.2m)	12 (Frontage of 2 glass panels of width 1.4m each)	
Add Value Machine (AVM) room (sqm)			1 AVM – 5sqm (2m wide frontage) 2 AVMs – 10sqm (4m wide frontage)		
Commercial Space, excluding circulation (sqm)			20% of concourse area, capped at 400		
ATM/ Public Phone/ Vending Machine Spaces (sqm)			7.5sqm (5nos. of 1.5sqm area)		
Canteen (sqm)			55 (Inclusive of 4.8sqm servery)	65 (Inclusive of 9.6sqm servery)	
Kitchen, adjacent to Canteen (sqm)			15	30	
Rodent-Free Storeroom, adjacent to Kitchen (sqm)			4.8		
Technician’s Room (sqm)			6		
Store Room (sqm)			6		
Cleaner’s Room, minimum door width 1.2m (sqm)			10		
First Aid Room cum Nursing Room (sqm)			7.5		
Special Purpose Room (sqm)			9		
Public Toilets (including handicap toilets)	Male	To follow NEA requirements + 1 extra set of cubicle, urinal and wash basin			
	Female	To follow NEA requirements			

1.4.3 Passenger Service Offices

- The two Passenger Service Offices 1 (For Primary Bus Operator) and 2 (For Secondary Bus Operator) shall be independent rooms with their own dedicated access. Doors shall be opened to the concourse area.
- Laminated glass panel and half wall with or without customised openings (for Bus Captain tapping machine) and with service counter top shall be provided, with the provision and dimension of the customised openings to be confirmed by the bus operators.
- The glass panel at the service counter shall be designed such that the passenger and the PSO staff can hear each other easily without the aid of microphone and speakers.

- (d) Motorised Aluminium Roller Shutters (with manual override) shall be provided 200mm behind the glass panel. Control Box to be provided beside the counter inside the room.
- (e) For details of the Passenger Service Offices, please refer to Drawings ref L/CFADC/AR/BI/0005 to L/CFADC/AR/BI/0008.
- (f) The CCTV viewing facilities, Building Management System's (BMS) Operator Workstation and Fire Repeater Panels shall be housed in the Passenger Service Office 1.

1.4.4 Staff Lounge cum Briefing Room

- (a) Foldable panel doors shall be provided within this room to segregate Staff Lounge and Briefing Room.
- (b) Room door shall be opened to the concourse area.

1.4.5 Ticket Office

- (a) Doors shall be opened to the concourse area.
- (b) Laminated glass panel and half wall with customised openings incorporating service counter top shall be provided.
- (c) Width of each counter shall be 1400mm. Please refer to Drawing ref L/CFADC/AR/BI/0009 to L/CFADC/AR/BI/0010
- (d) Motorised aluminium roller shutter (with manual override) shall be provided, subject to approval by the Authority. Control Box to be provided beside the counter inside the room.
- (e) Queue railings of clear width 700mm shall be provided, with the length, layout to be approved by the Authority. The design of queue rails shall cater for sufficient waiting space for passengers-in-wheelchair. Please refer to Drawings ref L/CFADC/AR/BI/0001.

1.4.6 Add Value Machine Room

- (a) Wall opening of size 1076mm (height) x 555mm (width) for Add Value Machine shall be provided for each room. The Please refer to Drawing ref. L/CFARC/AR/BI/0004.
- (b) The AVM Room can be combined with the Ticket Office with no separating wall, subject to Authority's approval.

1.4.7 Commercial Space

- (a) The Commercial Spaces shall be strategically located within the concourse.
- (b) The number of compartmentalised units shall be in the range of 15 to 30sqm.
- (c) These units shall be provided with a proper frontage facing the concourse, with a minimum depth of 3m.
- (d) A maximum of 50% of these units shall be equipped with wall kitchen exhaust system and grease trap for cooking purposes.
- (e) For air-conditioned bus interchange, these units shall have walls and motorised aluminium roller shutter (with manual override).
- (f) Other commercial developments shall not front the concourse, regardless of the amount of distance setback.

1.4.8 Canteen, Kitchen and Rodent-Free Store

- (a) The Kitchen shall be adjacent to the Canteen with the door opening to the Canteen.
- (b) The Rodent-Free Store shall be adjacent to the Kitchen with door opening to the Kitchen.
- (c) The servery area in the canteen shall be provided with one double bowl sink with drainer for every 4.8sqm.
- (d) One wash basin shall be provided in the canteen.
- (e) One double bowl sink with drainer shall be provided in the kitchen
- (f) The Kitchen shall be designed for cooking purposes and equipped with kitchen exhaust system and grease trap.

- (g) Motorised full-height aluminium roller shutter (with manual override) shall be provided for the canteen entrance.
- (h) All walls in the canteen and Kitchen shall be fully tiled.

1.4.9 Server Room

- (a) The door shall open to the Passenger Service Office 1. No window is needed.
- (b) The computer servers, CCTV backend equipment (e.g. CCTV recording facilities, CCTV network switches, etc) and BMS shall be housed in the Server Room.

1.4.10 Staff and Public Toilet Facilities

- (a) In addition to Staff Toilets, public toilet facilities shall be provided in the concourse.
- (b) The provision of public toilet facilities, including handicapped toilet, shall comply with NEA and BFA requirements. For public male toilet, one extra set of cubicle, urinal and wash basin shall be provided, in addition to NEA's requirement.
- (c) For all toilets, including Staff Toilets, heavy-duty auxiliary facilities including hand dryer, soap dispenser, mirror, toilet fixtures, jumbo toilet roll holder, door coat hooks, sanitary napkin disposal unit (for female toilets), etc shall be provided.
- (d) Handicap toilet shall preferably be provided with a heavy-duty sliding door.

1.4.11 Bin Centre/ Point and Electrical Substation (Outside Concourse)

- (a) A dedicated Bin Centre/ Point and Electrical Substation shall be provided in accordance with relevant authorities' requirements, with the location to be proposed for Authority approval.
- (b) The Bin Centre/ Point and Electrical Substation shall be located to facilitate efficient and safe operation of the bus interchange and shall be sheltered and away from concourse area. Footpath shall be provided for easy access, if necessary.
- (c) Vehicle lay-bys within the bus interchange space shall be provided for rubbish and power vehicles so that bus circulation and operations are not affected
- (d) Bin Centre shall be provided for refuse output exceeding 1,000L/day and shall be in accordance to NEA requirements.
- (e) Floor and walls in Bin Centre and Points shall be fully tiled.

1.4.12 Bicycle Parking Racks (Outside Concourse)

- (a) Bicycle parking racks shall be provided in the vicinity of the bus interchange.
- (b) A minimum of 40 bicycle parking racks shall be provided. Variations and addition to the number of bicycle parking racks shall be highlighted as required, dependent on the local catchment.
- (c) The location, distribution and design of the bicycle parking racks shall be proposed for Authority approval. Please refer to Drawings ref L/CFADC/AR/BI/0013 to L/CFADC/AR/BI/0014.

1.4.13 First Aid Room cum Nursing Room

- (a) A 1m (width) x 2.1m (height) door with single door leaf and clear opening shall be provided.
- (b) One wash basin with wall mounted mirror shall be provided.
- (c) Space for baby changing facilities which include a fold down changing table, shelf and facility to dispose of soiled diapers shall be provided.

1.4.14 Special Purpose Room

- (a) 1m long horizontal stainless steel railing fixed to back wall at 1m height

2	BUS BAYS
----------	-----------------

< Refer to Infrastructure Design Criteria>

3	SHELTERS
----------	-----------------

< Refer to Infrastructure Design Criteria>

4	PEDESTRIAN OVERHEAD BRIDGE AND PEDESTRIAN UNDERPASS
----------	--

< Refer to Infrastructure Design Criteria >

Commuter Facilities E&M Design Requirements

CONTENTS

1	INTRODUCTION	6
1.1	General	6
1.2	Acronyms and Definitions	6
1.3	Related Design Standard, Codes and Regulations	8
1.4	Submission Procedure	8
1.4.1	Pre-Submission Consultation	8
1.4.2	Design Submission	8
1.4.3	Amendment Submission	9
1.4.4	Completion of Works	10
1.4.5	As-Built Documentation Submission	11
2	DESIGN OBJECTIVES	12
3	GUIDELINE ON PEDESTRIAN OVERHEAD BRIDGE (POB) DESIGN	13
4	GUIDELINE ON PEDESTRIAN UNDERPASS DESIGN	14
5	GUIDELINES ON BUS SHELTER DESIGN	15
6	GUIDELINES ON TAXI / PASSENGER PICK-UP SHELTER DESIGN	16
7	GUIDELINES ON COVERED LINKWAY DESIGN	17
8	GUIDELINES ON BUS INTERCHANGE	18
8.1	Design Criteria	18
8.1.1	General	18
8.1.2	Concourse Area	18
8.1.3	Bus Parking Area / Driveway / Boarding & Alighting Berths	19
8.1.4	Passenger Service Office (PSO) 1	20
8.1.5	Passenger Service Office (PSO) 2	21
8.1.6	Administration Office	22
8.1.7	Manager's Office	22
8.1.8	Staff Lounge cum Briefing Room	23
8.1.9	Canteen	23
8.1.10	Store Room (Rodent Free)	24
8.1.11	Kitchen	24
8.1.12	Technician's Room	25
8.1.13	Ticket Office (TO)	25
8.1.14	Add Value Machine (AVM) Room	26
8.1.15	Store Room	26
8.1.16	Cleaner's Room	26
8.1.17	Server Room	27
8.1.18	Toilet Facilities (for both Public & Staff)	27
8.1.19	Other Facilities	28
8.2	Lighting Requirement For Bus Interchange	33
8.3	Lightning Protection System	33
8.4	Earthing System and Equipotential Bonding	34
8.5	Water Services, Sanitary Works and Pumped Drainage System	34
8.5.1	Water Services	34
8.5.2	Sanitary Works System	34
8.5.3	Pumped Drainage System	34
8.6	Passenger Lift (where applicable)	35
8.6.1	Design Requirements	35
8.7	Escalator (where applicable)	35

8.7.1	Design Requirement	35
8.7.2	Automatic Starting and Stopping Operation.....	35
8.8	Air-Conditioning and Mechanical Ventilation System.....	35
8.8.1	General	35
8.8.2	Ventilation for Bus Parking Area, Driveway and Boarding/Alighting Bay	37
8.9	Equipment Noise and Vibration	39
8.10	Fire Protection System in Bus Interchange.....	40
8.10.1	Automatic Fire Alarm System	40
8.10.2	Automatic Fire Sprinkler System	40
8.10.3	Fire Hydrant System	41
8.10.4	Dry Rising Main	41
8.10.5	Fire Hosereel System.....	41
8.10.6	Fire Extinguishers.....	41
8.11	Building Management System.....	41
8.12	Closed-Circuit Television (CCTV).....	42
8.13	One-way and Two-way Emergency Voice Communication Systems	43
9	GUIDELINES ON PUBLIC STREET LIGHTING DESIGN	44
10	INTERFACING WITH FACILITIES MANAGEMENT SYSTEM (FMS)	45
10.1	General	45
10.2	FMS Equipment.....	45
10.2.1	Programmable Logic Controllers.....	45
10.2.2	Field PLC Functional Requirements.....	46
10.2.3	Cabling and Wire Terminations.....	47
10.2.4	Telephone Line	47
10.2.5	Auxiliary Devices	47
10.2.6	Equipment Status Monitoring.....	48
10.2.7	Level Switches.....	48
10.2.8	Current Transformers and Voltage And Current Transducers	48
10.2.9	Wiring.....	48
10.3	Schedule of Points	48
11	TECHNICAL SPECIFICATIONS.....	50
11.1	Code and Regulation	50
11.2	LV Power Systems	50
11.2.1	LV Main Switchboard	50
11.2.2	LV Distribution Board (DB).....	53
11.2.3	Overground (OG) Box.....	54
11.2.4	Switchgear, Apparatus and Internal Wiring.....	55
11.2.5	LV Cables.....	58
11.2.6	Ancillary Equipment.....	58
11.3	Lighting Fixtures and Installation.....	59
11.3.1	General	59
11.3.2	Types of Lamps	60
11.3.3	Types of Light Fixtures	63
11.3.4	Intelligent Lighting Detection System.....	68
11.4	Lightning Protection System	69
11.4.1	General	69
11.4.2	Air Terminations.....	69
11.4.3	Down Conductors	70
11.4.4	Joints and Bonds.....	70
11.4.5	Earth Termination.....	70
11.5	Cable Support Systems.....	70

11.5.1	General	70
11.5.2	Metal Trunking and Accessories	71
11.5.3	Galvanised Iron Conduits and Accessories.....	71
11.5.4	Flexible Conduits.....	72
11.5.5	UPVC Conduit/Pipe and Accessories.....	72
11.5.6	Cable Tray and Accessories.....	72
11.6	Earthing System and Equipotential Bonding	72
11.6.1	General	72
11.6.2	Earth Termination.....	73
11.7	Emergency Diesel Generator System	73
11.7.1	General	73
11.7.2	Diesel Engine.....	74
11.7.3	Alternator.....	75
11.7.4	DC Electric Starting System	76
11.7.5	Control Panel	76
11.7.6	Fuel System	78
11.7.7	Generator Room Requirements	79
11.8	Water Services, Sanitary Works and Pumped Drainage System	79
11.8.1	Pipe work.....	80
11.8.2	Sewage Ejector Pumping System	80
11.8.3	Pumped Drainage System.....	80
11.8.4	Motor Control Panel	81
11.8.5	Motor Starter and Motor	82
11.8.6	Special Requirement for Motor of Sump Pumps	83
11.9	Passenger Lift	84
11.9.1	Design Requirements.....	84
11.9.2	Safety Requirements	85
11.9.3	Cable Requirements.....	87
11.9.4	Provisions for People with Special Needs	87
11.9.5	Lift Inter-Communication System	88
11.10	Escalators.....	88
11.10.1	Design Requirement	89
11.10.2	Energy Conservation Requirements	91
11.10.3	Machine Rooms/Pits and Closets	92
11.10.4	Cable Requirements.....	92
11.10.5	Safety Requirements.....	92
11.10.6	Corrosion Resistance And Material Requirements.....	93
11.11	Air-Conditioning And Mechanical Ventilation System.....	94
11.11.1	Pipe works	94
11.11.2	Sheet Metal Ductwork and Accessories	94
11.11.3	Ductwork Insulation	95
11.11.4	Pipe work Insulation	95
11.11.5	Air Filters.....	96
11.11.6	Air Curtain.....	96
11.11.7	Fans	97
11.11.8	Water-Cooled Chiller	98
11.11.9	Cooling Tower.....	98
11.11.10	Air Handling Unit (AHU).....	98
11.12	Fire Sprinkler System	99
11.12.1	Sprinkler Heads	99
11.12.2	Sprinkler Control Valve Set, Electrically Supervised Gate Valve and Accessories	100

11.12.3	Alarm Gong	100
11.12.4	Pressure Switches	101
11.12.5	Flow Switches.....	101
11.12.6	Pressure Gauges.....	101
11.12.7	Flow Meter	102
11.12.8	Sprinkler Tank	102
11.12.9	Sprinkler Breeching Inlets	103
11.12.10	Pumps	104
11.12.11	Fire Pump Control Panel	106
11.12.12	Miscellaneous	111
11.12.13	Pump Controls	112
11.13	Analogue Addressable Automatic Fire Alarm System	112
11.13.1	General	112
11.13.2	Operational Requirement.....	113
11.13.3	Main Alarm Panel.....	113
11.13.4	Fire Alarm Bell.....	116
11.13.5	Manual Call Point.....	117
11.14	Fire Hosereel & Hydrant System.....	117
11.14.1	General	117
11.14.2	Hosereel System	117
11.14.3	Hydrant System	119
11.14.4	Water Supply	119
11.14.5	Piping and Installation	119
11.15	Portable Fire Extinguishers.....	119
11.15.1	General	119
11.15.2	Installation	120
11.16	Pipework.....	120
11.16.1	General	120
11.16.2	Piping Installation.....	121
11.16.3	Installation of Pipe Hangers and Supports.....	122
11.16.4	Protection of Pipeworks.....	123
11.16.5	Pipework Materials.....	123
11.16.6	Pipe Joints.....	123
11.16.7	Pipe Fittings.....	123
11.16.8	Gaskets	124
11.16.9	Vertical and Riser Pipe Isolation	124
11.16.10	Horizontal Pipe Isolation	124
11.16.11	Sleeves and Covers.....	125
11.16.12	Stainless Steel Bellow Expansion Joints	125
11.16.13	Pipe Anchors	125
11.16.14	Valves, Cocks etc.	125
11.16.15	Cleaning Procedure.....	127
11.17	Surface Treatment.....	127
11.17.1	Corrosion Protection.....	128
11.17.2	Metal.....	128
11.17.3	Non-Metallic Materials.....	128
11.17.4	Bolts, Screws, Nuts.....	128
11.17.5	Painting.....	128
12	APPENDICES	130
	APPENDIX 2 TYPICAL CONTROL AND MONITORING POINT SCHEDULE FOR BUILDING MANAGEMENT SYSTEM.....	130

1 INTRODUCTION

1.1 General

This document, which is also called the Electrical and Mechanical Design Criteria for Commuter Facilities (EMDC CF), defines the criteria and requirements for the design, supply, installation, testing and commissioning of the Electrical and Mechanical (E&M) services for Bus Interchanges.

The Authority shall be highlighted of any contradiction or conflicts within the criteria set out hereafter. In addition, the Authority shall be notified and acceptance shall be sought for any change or new requirements that may arise during the works.

1.2 Acronyms and Definitions

Air Changes	A method of expressing the rate of air entering or leaving a space by natural or mechanical means in terms of the number of volumes of the spaces.
Air-Conditioning	The process of treating air so as to control simultaneously its temperature, humidity, cleanliness and distribution to met the requirements of the conditioned space.
Authority	Land Transport Authority
Colour rendering	A general expression for the appearance of colours when illuminated by light form a given source compared, consciously or unconsciously with their appearance under light from some reference source.
Colour temperature	The temperature of a full radiator, which emits radiation of the same chromaticity as the radiator considered. (The unit is Kelvin).
Contractor	Contractor or Designer
Designer	The developer, contractor or consultant employed by the Authority, developer or contractor to carry out the design of the M&E services.
Emergency Lighting	Lighting provided for use when the supply to the normal lighting fails.
Equipotential Bonding	Electrical connection maintaining various exposed-conductive-parts and extraneous conductive parts at substantially the same potential.
Exit Light	The part of emergency lighting, which provide to luminaire the exits.
FMS	Facilities Management System
Glare	The discomfort or impairment of vision experienced when parts of the visual field are excessively bright in relation to the general surrounding.

<u>Luminaire</u>	Apparatus, which distributes, filters and transforms the light given by a lamp or lamps and which includes all the items necessary for fixing and protecting these lamps and for connecting them to the supply circuit.
Illuminance	The luminous flux density at a surface, i.e. luminous flux incident per unit area. The unit of illuminance is lux.
Lighting point	A termination of a fixed wiring system intended for the attachment of a luminaire.
Mains	Incoming Electricity supply.
Mounting Height	The vertical distance between a luminaire and the working plane.
Operator	Party operating and maintaining the Bus Interchange including the E&M equipment and plant.
PUP	Pedestrian Underpass
Uniformity Ratio	The ratio of the minimum illuminance to the average illuminance applied to the values on the working plane.
Ventilation	The process of supplying or removing air, by natural or mechanical means, to or from any space. Such air may or may not have been conditioned.

1.3 Related Design Standard, Codes and Regulations

Unless otherwise stated, the mechanical and electrical works for commuter facilities shall be governed by all applicable local regulations, codes, standards and requirements issued by all relevant authorities having jurisdiction, which shall include but not limited to the following:

- Public Utility Board (PUB)
- Singapore Civil Defence Force (SCDF)
- Building Control Authority (BCA)
- Ministry of the Environment and Water Resources
- National Environment Agency (NEA)
- National Parks Boards (NParks)
- Energy Marketing Authority
- Productivity and Standards Board (PSB)
- Land Transport Authority (LTA)
- Standards, Productivity and Innovation Board (SPRING)

Where there are discrepancies or conflicts between the above, the attention of the Authority shall be sought for final decision. Compliance with the EMDC CF criteria shall not preclude the need to obtain full clearance and approval from the Authority's Development and Building Control Division (DBC), the Authority and all authorities having jurisdiction.

1.4 Submission Procedure

1.4.1 Pre-Submission Consultation

Pre-submission consultation with the Authority may be applied through the Development and Building Control Division (DBC) where submission involves non-compliance to the EMDC CF requirements; Application for approval or waiver or modifications shall be submitted to the Authority through the DBC.

All relevant Authorities Having Jurisdiction (AHJ) such as NParks, PUB, Power Grid Ltd, Power Supply Ltd, LTA, etc shall be pre-consulted before embarking on the design of the commuter facilities. All such pre-consultation shall be minuted and these minutes shall be submitted to the Authority and AHJ as records.

1.4.2 Design Submission

Two (2) sets of the documents listed below shall be submitted, in the appropriate format, when seeking approval from the Authority and prior to commencement of works.

All drawings and calculations shall be certified by the Qualified Person (QP).

No works shall commence until approval of the subject design and relevant waiver is obtained from the Authority in writing.

1.4.2.1 General

- Site and location plan showing the source of the incoming power and water supply and indicate the area that is to be hand-over to LTA.

1.4.2.2 Electrical Installations

- Single line diagrams for the electrical installation.
- Lighting and power layout plans including schematic diagrams showing the OG box layouts and cable routing plans.
- Earthing system schematics and layout plans.
- All electrical calculations to substantiate selection of plant and equipment. The submission shall include circuit breaker and cable sizing, fault level calculations, discrimination setting between various breakers and etc.
- Catalogues with all relevant test certificates to demonstrate compliance with specified and performance requirements.
- Lighting design calculations to substantiate that the design is in accordance with the design criteria and specified requirements.
- Lightning Protection System shall design in accordance to the latest edition Code of Practice, SS 555.

1.4.2.3 Mechanical System Installations

- Air-conditioning and Mechanical Ventilation System Design
- Fire Protection System Design
- All services routing, installation detail and sizes
- Properly dimensioned layout diagrams showing the location of equipment
- Equipment installation details
- Control and monitoring system and strategy for the mechanical system
- Calculations including cooling load calculation, mechanical ventilation calculations, pump capacity sizing, operating pumping head and pump operating levels (start/stop, alarm level, etc), fan pressure calculations, cable sizing, voltage drop calculations, motor starter capacity, etc.
- Calculations on the mounting, inertia blocks vibration isolations and noise controls.
- Structural equipment bases, supports and tank details
- Catalogues and technical specifications for the equipment, materials and accessories

1.4.3 Amendment Submission

The Authority shall be notified of any deviations from the approved plans and the revised plans shall be submitted to the Authority for acceptance before any deviation works commenced.

1.4.4 Completion of Works

1.4.4.1 Testing and Commissioning and Hand-over to the Authority

Upon completion of the mechanical and electrical works, visual inspections and all necessary testing and commissioning shall be performed to demonstrate compliance with the design and specified requirements. The test results which shall be endorsed by the QP shall be submitted to the Authority for acceptance. Instruments used for the tests shall have a valid calibration certificate. The calibration certificates shall be submitted together with the test results. The tests which shall be conducted shall include but not limited to the following:

- 1) Site Lux Level Measurement Test Results for Lighting System.
- 2) Electrical System Tests
 - Insulation voltage test with appropriate insulation tester
 - Earth loop impedance test
 - Continuity test on the conductor & joints
 - Polarity and phase sequence
- 3) Earth Resistance Test Results for Lightning Protection System
- 4) Mechanical System Tests
 - Individual Equipment and System Performance Tests
 - Air and Water Balancing Test
 - Hydraulic Test
 - Pump Test
 - Operation and Control Function Tests
 - Noise Level Measurement

The Authority shall be given at least 7 days advanced notice of any joint inspection or tests. The Designer shall rectify all defects identified during the joint inspections and a final joint inspection to certify the clearance of all defects shall be arranged.

1.4.5 As-Built Documentation Submission

Two (2) sets of the as-built drawings, testing and commissioning results endorsed by the QP and operation and maintenance (O&M) manuals for the electrical and mechanical installations, shall be submitted to the Authority, prior to handing over to the commuter facility to the Authority. These shall include but not limited to the following:

1.4.5.1 Electrical Installations

- As-built electrical single line diagrams
- As-built Lighting and power layout plans / As-built Earthing system schematics and layout plans / As-built Lightning protection system layout plans.
- Testing and commissioning results of the lighting level and electrical installation
- Testing and commissioning results of the Lightning Protection System and certificate of supervision for Lightning Protection is in accordance to the latest edition of Code of Practices, SS 555.

1.4.5.2 Mechanical Installations

- As-built mechanical services plan
- Testing and commissioning results of the mechanical services and related electrical installation
- Approved mechanical services plans to authorities
- Verification of the proper functioning of the equipment and system
- Verification on the performance of the installed equipment and system meeting the specified design life.
- All tests required by the relevant authorities

2 DESIGN OBJECTIVES

< Refer to Infrastructure Design Criteria>

3	GUIDELINE ON PEDESTRIAN OVERHEAD BRIDGE (POB) DESIGN
----------	---

< Refer to Infrastructure Design Criteria>

4	GUIDELINE ON PEDESTRIAN UNDERPASS DESIGN
----------	---

< Refer to Infrastructure Design Criteria>

5 GUIDELINES ON BUS SHELTER DESIGN
--

< Refer to Infrastructure Design Criteria>

6	GUIDELINES ON TAXI / PASSENGER PICK-UP SHELTER DESIGN
----------	--

< Refer to Infrastructure Design Criteria >

7	GUIDELINES ON COVERED LINKWAY DESIGN
----------	---

< Refer to Infrastructure Design Criteria>

8	GUIDELINES ON BUS INTERCHANGE
----------	--------------------------------------

8.1 Design Criteria

In addition to the requirements as specified elsewhere in the document, the design of the bus interchange shall also comply with the requirements stated herein.

8.1.1 General

- a) Dedicated M&E services, sewerage system, drainage services, telecommunication systems, water supply systems and incoming utility services shall be provided with the sole purpose to serve the functions of the Bus Interchanges.
- b) All utilities and services provided to serve the Bus Interchanges shall be connected at the intake point with separate metering provision.
- c) A kWh meter shall be provided for each of the following areas:
 - Concourse
 - Each commercial space unit
 - Canteen
 - PSO 2
 - AVM Room and Ticket Office
 - Rest of the Offices
 - Air-condition plant
 - Mechanical ventilation plant
 - Bus parking area

8.1.2 Concourse Area

a	Lighting	Minimum 150 lux measured at floor level with uniformity ratio of 0.3. Means of varying the lighting level via timer relay control to achieve 33%, 66% and 100 % lighting level shall be provided in the design.
b	Emergency / Battery back-up lighting 2hrs for evacuation	As per SS 563
c	Emergency Lighting System; 6 hours for continuous operation	Average of 10 lux for 6 hours
d	Signage, information board & advertising panel	13A Fused Connection Unit with male /female adapter to be located within each lighted sign / information board / advertising panel.
e	Public Telephone Points	Minimum 4 nos. with power points and telephone points. As per latest IDA guidelines.

f	General power points	<ul style="list-style-type: none"> - For standalone bus interchange, a 13A flush type switch socket outlet (SSO) complete with weatherproof and lockable cover shall be provided and mounted at 300mm height at each boarding location. - For integrated bus interchange, 1 no. 13A flush type SSO complete with lockable cover shall be provided and mounted at 300mm height at each boarding/concourse location. - 1 no. 13A SSO shall be provided near each EIDS (Electronic Information Display System). - Each EIDS shall be controlled by a fused switch at the PSO. - A 13A SSO shall be provided adjacent to each oscillating fan.
g	Water Services	Minimum 2 tap points shall be provided and enclosed by stainless steel casing with pad lock for standalone bus interchange only.
h	Sanitary Works	Floor wastes/trap for connection to condensate drainage pipes from the air-conditioning units shall be provided
i	Mode of ventilation	<p>a) Natural ventilation with industrial type oscillating fans shall be provided for the queuing area of standalone bus interchange. Sufficient number of fans shall be provided to ensure proper coverage. Each oscillating fan shall have an on/off switch and speed controller.</p> <p>b) Air-conditioning for integrated bus interchange. For the design of the air-conditioning system, the following shall be assumed:</p> <ul style="list-style-type: none"> (i) Number of occupants: 3m² per person (ii) Minimum fresh air supply: 5 l/s per person
j	Automated Screen Doors	Automated screen doors (ASD) to be equipped with auto-lock mechanism when powered down locally at each individual screen doors during non-operation hours shall be provided. Alternative means of powering down each ASD shall be provided at the PSO office for remote control by the operator.

8.1.3 Bus Parking Area / Driveway / Boarding & Alighting Berths

a	Lighting	<u>Integrated Bus Interchange</u> <ul style="list-style-type: none"> - Entrance/Exit – 100/50 lux (day/night) measured at floor level with a uniformity of 0.3. - Ramps and Corners - 75 / 50 lux (day/night) measured at floor level with a uniformity of 0.3.
---	----------	---

		<ul style="list-style-type: none"> - Bus Park - 75 / 20 lux (day/night) measured at floor level with a uniformity of 0.3. <p><u>Standalone Bus Interchange</u></p> <ul style="list-style-type: none"> - Entrance/Exit - 20 lux measured at floor level with a uniformity of 0.3. - Ramps and Corners -50 lux measured at floor level with a uniformity of 0.3. - Bus Park - 15 lux measured at floor level with a uniformity of 0.3.
b	Emergency power for lightings; (For integrated Bus interchange only).	In the event of a PG incoming power failure, the power supply serving the emergency lighting system shall be provided by EPS (10 minutes ride through) and continuous power supply by the generator to achieve average 10 lux for 6 hours.
c	Emergency lighting 2hrs for evacuation	As per SS 563
d	Loop Detector	Associated power supply provisions for loop detectors to be provided for the operation of auto-doors within the Integrated Bus Interchange.
e	General power points	<ul style="list-style-type: none"> - 13A SSO within weatherproof lockable metal cabinets shall be provided and mounted at 1.4m height. - Note: All general purpose power points shall be protected by residual current circuit breaker (RCCB).
f	Water Services	Tap points shall be provided at every 60 m interval and enclosed by stainless steel casing with pad lock.
g	Sanitary Works	To provide according to relevant code requirement.
h	Mode of Ventilation	Natural Ventilation as described in Section 8.8.2

8.1.4 Passenger Service Office (PSO) 1

a	Lighting	300 lux measured at 0.7m working plane with uniformity ratio of 0.3.
b	Emergency / Battery back-up lighting 2hrs for evacuation	As per SS 563
c	Mode of Ventilation	<p>Air-conditioning by:</p> <ul style="list-style-type: none"> a) Air-cooled split unit for standalone bus interchange b) Chilled water fan coil unit for integrated bus interchange.

d	Power Points for equipment	Minimum 20 nos. 13A SSO mounted at 300mm height from FFL. 1 no. weatherproof isolator of appropriate rating to be provided at each condenser unit location.
e	Telephone outlet	- Minimum 4 nos. to be located at each wall of the Passenger Service Office mounted at 300mm height from FFL. - Conduits/Trunkings with draw wire only will be provided for computer cables.
f	Sanitary Works	Floor waste/trap for connection of the air-conditioning drain shall be provided.
g	Others	BMS operator workstation and Fire Repeater Panel shall also be provided in this room.

8.1.5 Passenger Service Office (PSO) 2

a	Lighting	300 lux measured at 0.7m working plane with uniformity ratio of 0.3.
b	Emergency / Battery back-up lighting 2hrs for evacuation	As per SS 563
c	Mode of Ventilation	Air-conditioning by: a) Air-cooled split unit for standalone bus interchange b) Chilled water fan coil unit for integrated bus interchange.
d	Power Points for equipment	Minimum 10 nos. 13A SSO shall be provided and mounted at 300mm height from FFL. 1 no. weatherproof isolator of appropriate rating to be provided at each condenser unit location.
e	Telephone outlet	- Minimum 1 no. shall be provided at each wall of the Passenger Service Office mounted at 300mm height from FFL. - Conduits/Trunkings with draw wire only shall be provided for computer cables.
f	Sanitary Works	Floor waste/trap for connection of the air-conditioning condensate drain pipe shall be provided.

8.1.6 Administration Office

a	Lighting	400 lux measured at 0.7m working plane with uniformity ratio of 0.3.
b	Emergency / Battery back-up lighting 2hrs for evacuation	As per SS 563
c	Mode of Ventilation	Air-conditioning by: a) Air-cooled split unit for standalone bus interchange. b) Chilled water fan coil unit for integrated bus interchange.
d	Power Points for equipment	Minimum 8 nos. 13A SSO shall be provided, mounted at 300mm height from FFL. 1 no. weatherproof isolator of appropriate rating to be provided at each condenser unit location.
e	Telephone outlet	Minimum 3 nos. shall be provided, mounted at 300mm height from FFL. Conduits/Trunkings with draw wire only will be provided for computer cables.
f	Sanitary Works	Floor waste/trap for connection to condensate drainage pipes from the air-conditioning units.

8.1.7 Manager's Office

a	Lighting	400 lux measured at 0.7m working plane with uniformity ratio of 0.3.
b	Emergency / Battery back-up lighting 2hrs for evacuation	As per SS 563
c	Mode of Ventilation	Air-conditioning by: a) Air-cooled split unit for standalone bus interchange. b) Chilled water fan coil unit for integrated bus interchange.
d	Power Points for equipment	Minimum 8 nos. 13A SSO shall be provided, mounted at 300mm height from FFL. 1 no. weatherproof isolator of appropriate rating to be provided at each condenser unit location.
e	Telephone outlet	Minimum 3 nos. shall be provided, mounted at 300mm height from FFL. Conduits/Trunkings with draw wire only will be provided for computer cables.
f	Sanitary Works	Floor waste/trap for connection to condensate drainage pipes from the air-conditioning units.

8.1.8 Staff Lounge cum Briefing Room

a	Lighting	200 lux measured at 0.7m working plane with uniformity ratio of 0.3.
b	Emergency / Battery back-up lighting 2hrs for evacuation	As per SS 563
c	Mode of Ventilation	Air-conditioning by: a) Air-cooled split unit for standalone bus interchange. b) Chilled water fan coil unit for integrated bus interchange.
d	Power Points for equipment	Minimum 6 nos. 13A SSO shall be provided, mounted at 300mm height from FFL. 1 no. weatherproof isolator of appropriate rating to be provided at each condenser unit location.
e	Telephone outlet	Minimum 1 no. shall be provided, mounted at 300mm height from FFL.
f	Water Services	Water points for basin and water dispenser
g	Sanitary Works	Floor waste/trap for connection to condensate drainage pipes from the air-conditioning units, basin and water dispenser shall be provided.

8.1.9 Canteen

a	Lighting	200 lux measured at 0.7m working plane with uniformity ratio of 0.3.
b	Emergency / Battery back-up lighting 2hrs for evacuation	As per SS 563
c	Power Points for equipment	Minimum 5 nos. 13A SSO shall be provided, mounted at 300mm height from FFL. 1 no. weatherproof isolator of appropriate rating to be provided at each condenser unit location. A 13A SSO shall be provided adjacent to each oscillating fan.
d	Mode of Ventilation	a) Natural ventilation with industrial type oscillating fans for standalone bus interchange. Each oscillating fan shall have an on/off switch and speed controller. b) Air-conditioning using chilled water fan coil unit for integrated bus interchange
e	Water Services	Water points for sinks and tap points for washing. PUB sub meters for canteen operators

f	Sanitary Works	Floor wastes/traps for connection to condensate drainage pipes from the air-conditioning units, sinks, etc.
g	Others	Canteen shall be provided with individual distribution board located within the canteen premises. All electrical circuits within the canteen shall originate from this distribution board.

8.1.10 Store Room (Rodent Free)

a	Lighting	100 lux measured at 0.7m working plane with uniformity ratio of 0.3.
b	Emergency / Battery back-up lighting 2hrs for evacuation	As per SS 563
c	Power Point	Minimum 1 no. of 13A SSO shall be provided, mounted at 1400mm height from FFL.
d	Oscillating fan	1 no. wall mounted type oscillating fan with 13A SSO next to the fan and a switch next to the lighting switch shall be provided.
e	Mode of Ventilation	Natural Ventilation

8.1.11 Kitchen

a	Lighting	300 lux measured at 0.7m working plane with uniformity ratio of 0.3.
b	Emergency / Battery back-up lighting 2hrs for evacuation	As per SS 563
c	Oscillating fan	1 no. wall mounted type oscillating fan with a 13A SSO next to the fan and a switch next to the lighting switch shall be provided.
d	Power Points for equipment	<ul style="list-style-type: none"> - Minimum 5 nos. 13A SSO shall be provided, mounted at 300mm height from FFL linked to the kWh meter for canteen operator - 1 no. power point of appropriate rating shall be provided for the electrical cooking equipment. - A 13A SSO shall be provided adjacent to each oscillating fan.
e	Kitchen exhaust system	Kitchen exhaust system complete with associated ducting and electrical cabling works shall be provided.
f	Mode of ventilation	a) Natural ventilation with industrial type oscillating fan for standalone bus interchange. Each oscillating fan shall have an on/off switch and speed controller.

		b) Mechanical ventilation for integrated bus interchange.
g	Water Services	Water points for sinks and tap points for washing, linked to the PUB sub meter for canteen operator
h	Sanitary Works	Floor wastes/traps for connection of the sinks, grease trap, etc.
i	Others	All electrical circuits within the Kitchen shall originate from the distribution board in Canteen.

8.1.12 Technician's Room

a	Lighting	200 lux measured at 0.7m working plane with uniformity ratio of 0.3.
b	Emergency / Battery back-up lighting 2hrs for evacuation	As per SS 563
c	Oscillating fan	1 no. wall mounted oscillating fan with 13A SSO to be provided at the oscillating fan location with switch next to lighting switch.
d	Power Points for equipment	Minimum 2 nos. 13A SSO shall be provided mounted at 1400mm height from FFL.
e	Mode of Ventilation	Natural Ventilation

8.1.13 Ticket Office (TO)

a	Lighting	300 lux measured at 0.7m working plane with uniformity ratio of 0.3.
b	Emergency / Battery back-up lighting 2hrs for evacuation	As per SS 563
c	Mode of Ventilation	Air-conditioning by: <ul style="list-style-type: none"> a) Air-cooled split unit for standalone bus interchange b) Chilled water fan coil unit for integrated bus interchange.
d	Power Points for equipment	Minimum 3 nos. 13A SSO per sales position shall be provided mounted at 300mm height from floor level. 2 nos. 13A SSO shall be provided near the 3 rd table. Total shall be 8 nos. (2 sales positions) for a 4m x 3m TO. 1 no. weatherproof isolator of appropriate rating to be provided at each condenser unit location.
e	Telephone outlet	Minimum 5 nos. to be provided next to the power points.
f	Sanitary Works	Floor waste/trap for connection of the air-conditioning unit's condensate drainage pipes shall be provided.

g	Others	Ticket Office shall have its individual distribution board located within the Ticket Office. All electrical circuits within these rooms shall originate from this distribution board.
---	--------	---

8.1.14 Add Value Machine (AVM) Room

a	Lighting	200 lux measured at 0.7m working plane with uniformity ratio of 0.3.
b	Emergency / Battery back-up lighting 2hrs for evacuation	As per SS 563
c	Oscillating fan	1 no. wall mounted oscillating fan with 13A SSO to be provided at the oscillating fan location with switch next to lighting switch.
d	Power Points for equipment	Minimum 4 nos. 13A SSO per sales position shall be provided mounted at 300mm height from FFL. Power points should be positioned at least 200mm away from side of AVM opening.
e	Telephone outlet	Minimum 3 nos. to be located 50mm below the power points. Telephone outlet should be positioned at least 200mm away from side of AVM opening.
g	Mode of Ventilation	Natural Ventilation

8.1.15 Store Room

a	Lighting	100 lux measured at 0.7m working plane with uniformity ratio of 0.3.
b	Power Point	Minimum 1 nos. 13A SSO shall be provided mounted at 1400mm height from FFL.
c	Oscillating fan	1 no. wall mounted oscillating fan with 13A SSO to be provided at the oscillating fan location with switch next to lighting switch.
d	Mode of Ventilation	Natural Ventilation

8.1.16 Cleaner's Room

a	Lighting	100 lux measured at 0.7m working plane with uniformity ratio of 0.3.
b	Power Point	Minimum 1 nos. 13A SSO shall be provided mounted at 1400mm height from FFL.
c	Oscillating fan	1 no. wall mounted oscillating fan with 13A SSO to be provided at the oscillating fan location with switch next to lighting switch.

d	Mode of Ventilation	Natural Ventilation
---	---------------------	---------------------

8.1.17 Server Room

a	Lighting	300 lux measured at 0.7m working plane with uniformity ratio of 0.3.
b	Emergency / Battery back-up lighting 2hrs for evacuation	As per SS 563
c	Mode of Ventilation	Air-conditioning - 24 hours air-conditioning using air-cooled split units with 100% standby provision. - The duty and standby air-conditioning units shall operate alternately on a 7-day timer cycle. The standby unit shall automatically cut-in in case of failure of the duty unit.
d	Power Points for equipment	6 nos. 13 A SSO shall be provided mounted at 300mm height FFL. 1 no. weatherproof isolator of appropriate rating to be provided at each condenser unit location.
e	Telephone outlet	2 nos. to be provided mounted at 300mm height from FFL.
f	Sanitary Works	Floor waste/trap for connection to condensate drainage pipes from the air-conditioning units.
g	Others	A distribution board shall be provided to serve the server room and to be located within the room. Building Management System shall be housed in this room.

8.1.18 Toilet Facilities (for both Public & Staff)

a	Lighting	- 300lux measured at 0.7m working plane with uniformity ratio of 0.3. - Downlight will be used where false ceilings are installed.
b	Emergency / Battery back-up lighting 2hrs for evacuation	As per SS 563
c	Oscillating fan	Industrial type oscillating fans shall be provided with 13A SSO adjacent to each oscillating fan. Each oscillating fan shall have an on/off switch and speed controller.

d	Hand Dryer	1 no. hand dryer to be provided at each toilet. 1 no. 15A Fused Connection Unit to be located above ceiling & 1 no. switch with neon indicator to be located next to toilet light switch.
e	Auto-flushing	1 no. 13A SSO to be mounted above ceiling for each unit.
f	Lights, wall fans & exhaust fans	The oscillating fans and mechanical exhaust fans shall be interlocked with the lighting switch.
g	Water Services	<ul style="list-style-type: none"> - Tap points for washing and water supply for water/sanitary fixtures/fittings. - Water closets and urinals at the public toilets shall be provided with automatic sensor flush valves. All piping shall be concealed.
h	Sanitary Works	<ul style="list-style-type: none"> - Floor wastes/traps and sanitary works for water/sanitary wares. - All piping shall be concealed.
i	Mode of Ventilation	<ul style="list-style-type: none"> - Mechanical ventilation at 20 air-changes per hour for public toilets. - Exhaust air from the toilet shall not be discharged into the bus boarding, alighting and queuing areas, pedestrian thoroughfares, trafficable areas and areas of public access.
j	Emergency call bell system	1 no. 13A SSO shall be provided above the ceiling of handicapped toilet to serve the emergency call bell system including audio and visual display units located outside the toilet and in the PSO. In addition, a mute button for the emergency call bell system shall be provided in the PSO.
k	Others	1 no. weatherproof padlockable 13A SSO to be mounted at 0.3m per toilet at entrance of toilet for portable blower for drying of floor.

8.1.19 Other Facilities

a	Commercial Space	<ul style="list-style-type: none"> - A 30A single phase Distribution Board shall be provided for each commercial space unit less than 15 m² - A 60 A 3 phase Distribution Board shall be provided for each commercial space unit between 15m² and 100 m² - A 3 phase Distribution Board of appropriate rating shall be provided for each commercial space unit greater than 100 m² - 1 no. telephone outlet shall be provided in each commercial space unit. - Air-conditioning:
---	------------------	---

		<ul style="list-style-type: none"> (i) Independent air-cooled split system shall be provided for each commercial space unit in standalone bus interchange (ii) Chilled water fan coil unit(s) for commercial space units in integrated bus interchange. <ul style="list-style-type: none"> - Power supply for the air-conditioning unit shall be taken from the Distribution Board serving the commercial space unit. - 1 no. weatherproof isolator shall be provided at each condenser unit location. - A Btu Meter shall be provided for each commercial space unit served by chilled water fan coil unit(s). - A water sub-meter shall be provided for each commercial space unit. - 50% of the commercial spaces shall be provided with kitchen exhaust system complete with associated ducting and electrical cabling works. - Water tap-off point and floor wastes/traps shall be provided in each commercial space unit. - Floor wastes/traps for connection of the sinks, grease trap, etc shall be provided in each commercial space unit designated with cooking facilities. <p>(Lighting within the commercial space units will be provided by the Tenants)</p>
b	ATM space	<ul style="list-style-type: none"> - 2 nos. 13A SSOs shall be provided for each ATM and mounted at 300mm height above FFL - 2 nos. Telephone point/socket shall be provided for each ATM and located next to the SSO
c	Bin Centre (where refuse output exceeds 1000L/day, otherwise bin point only)	<ul style="list-style-type: none"> - 1 no. 13A SSO (weatherproof) - 1 no. water tap point - Cast iron gully trap - Natural Ventilation - 100 lux
d	Switch Room	<ul style="list-style-type: none"> - 200 lux - Emergency Lighting as per SS563 - Light Fittings with Battery packs to be placed to light up front of Switchboards - 1 no 13A SSO

		<ul style="list-style-type: none"> - Size of room should not be less than 11 m². Min. 600mm all round the main switch board and emergency switch board - Natural / Mechanical Ventilation - 1 no. oscillating fan to be interlocked with light switch if the room is naturally ventilated
e	Emergency power for Integrated Bus Interchange	<ul style="list-style-type: none"> - Essential loads to be separated from normal load. Essential loads shall consist of sump pumps, lifts, ejector pumps, fire related mechanical ventilation system, fire protection system, emergency lighting system and lighting and air-conditioning system for Server Room and FCC - 5-pin industrial socket outlets (male & female) for connection for DBs in MDF room for mobile generator connection as per IDA requirement. Rating of socket outlet shall be suitable to supply essential loads. 1 no. External lockable weather proof mobile generator connection board/box to supply power to main switch board of bus interchange during Powergrid incoming failure. The mobile generator connection board/box shall be rated at 100% capacity of main switch board for Standalone bus interchange and rated at 100% capacity of emergency main switch board for integrated bus interchange
f	Escalators Control Closets	<ul style="list-style-type: none"> - 150 lux - 1 no power isolator of an 80A TPN rating, 1 no. single phase isolator for EBOPS serving the comb lightings and SSO - EBOPS to be installed in escalator controller closet - ITB for FMS/BMS monitoring, if any - Natural Ventilation - Heat detector protection
g	Escalators Pits	<ul style="list-style-type: none"> - 1 no. 13A weatherproof SSO - 1 no. weatherproof light fittings with switch for upper and lower pits respectively - Sprinkler protection - Drainage pipe to discharge into sump/drainage system
h	Lift Pit/Hoistways	<ul style="list-style-type: none"> - The base of lift pit shall be graded to have a minimum fall of 1:200 towards a dry sump of 450mm by 450mm by 450mm - 1 no. 1x36W weatherproof light fitting with switch - 1 no. weatherproof 13A SSO

i	Motor Control Centre (MCC) room	<ul style="list-style-type: none"> - 200 lux - Emergency Lighting as per SS563 - 1 no. power isolator of appropriate rating shall be provided for each motor control centre/local control panel - Natural / Mechanical Ventilation - 1 no. oscillating fan to be interlocked with light switch if room is naturally ventilated
j	Fire Pump Room	<ul style="list-style-type: none"> - 200 lux - 2 nos. 13A SSO weatherproof - Emergency Lighting as per SS563 - 1 no. power isolator of appropriate rating shall be provided for each motor control centre / local control panel
k	Ejector Pump Room	<ul style="list-style-type: none"> - 1 no power isolator of appropriate rating shall be provided at the sump or ejector pump control panel - 1 no. 13A SSO weatherproof padlockable SSO to be located next to sump or ejector pump control panel
l	Sump Pump Room	<ul style="list-style-type: none"> - 200 lux - One tap point for washing - Floor waste/trap - Mechanical Ventilation
m	Sewage Ejector Room	<ul style="list-style-type: none"> - 200 lux - One tap point for washing - Drainage to sewage ejector pumping system - Mechanical Ventilation
n	Sprinkler / Hose Reel Tank Room	<ul style="list-style-type: none"> - 200 lux - Emergency Lighting as per SS563 - 1 no. 13A SSO weatherproof - One tap point for washing - Floor waste/trap - Natural ventilation
o	AHU Room	<ul style="list-style-type: none"> - 200 lux - Emergency Lighting as per SS563 - 2 no. Twin 13A SSO - Tap points for washing - Floor wastes/traps - Air-conditioning
p	Chiller Plant Room	<ul style="list-style-type: none"> - 200 lux - Emergency Lighting as per SS563 - 2 no. Twin 13A SSO

		<ul style="list-style-type: none"> - Tap points for washing - Floor wastes/traps - Natural ventilation. - Refrigerant leak detection system and exhaust system shall be provided. The refrigerant leak detection system shall interlock with the exhaust system.
q	Cooling Tower / Condenser Area	<ul style="list-style-type: none"> - 200 lux - Emergency Lighting as per SS563 - 2 nos. 13A SSO weatherproof - Tap points for washing - Floor wastes/traps - 1 no. weatherproof power point shall be provided for maintenance - Natural Ventilation
r	Distribution Board (DB) Room	<ul style="list-style-type: none"> - 200 lux - 2 no. 13A SSO - Emergency Lighting as per SS563 - Natural Ventilation
s	Entrance / Exit	<ul style="list-style-type: none"> - 150 lux - Emergency Lighting as per SS563 - 1 no. 13A SSO (To provide Exit Light at the max mounting height of 2.4m)
t	Emergency exit staircase	<ul style="list-style-type: none"> - 150 lux - Emergency Lighting as per SS563. - 1 no. 13A SSO at top and bottom of main staircase landing - Natural Ventilation
u	Fire command centre(FCC) if required by SCDF	<ul style="list-style-type: none"> - 150 lux - Emergency lighting as per SS563 - Power points as required by design - To comply with local building fire code requirements inclusive of provision of air-conditioning using air-cooled split units
v	First Aid Room cum Nursing Room	<ul style="list-style-type: none"> - 300 lux - Emergency Lighting as per SS563 - Tap points for washbasin - Floor wastes/traps - 4 no. 13A power point - Air-conditioning by: <ul style="list-style-type: none"> a) Air-cooled split unit for standalone bus interchange. b) Chilled water fan coil unit for integrated bus interchange
w	Special Purpose Room	<ul style="list-style-type: none"> - 500 lux - Emergency Lighting as per SS563 - Tap points for washbasin

		<ul style="list-style-type: none"> - Floor wastes/traps - 2 nos. twin 13A power point - AMS door lock - Handrail - Air-conditioning by: <ul style="list-style-type: none"> a) Air-cooled split unit for standalone bus interchange. b) Chilled water fan coil unit for integrated bus interchange.
x	Generator Room	<ul style="list-style-type: none"> - 200lux - Emergency Lighting as per SS563 - Light fittings with battery packs to be placed to light up front of switchboards - 1 no 13A SSO. - Size of room as required by design - Natural / Mechanical Ventilation

Note:

Notwithstanding the above requirements, the Contractor shall comply with the local codes, regulations and requirements of the authorities having jurisdiction. The Contractor shall also co-ordinate with the Operator for all the necessary information and data in order to complete his designs and works.

8.2 Lighting Requirement For Bus Interchange

- a) Light fitting shall be of energy efficient design. No up-lighters shall be used in the lighting design.
- b) For perimeter light fittings and where light fittings are exposed to weather, the fittings shall be IP65, vandal proof, designed to minimum IK06, ultra-violet (UV) stabilized and aesthetically acceptable.
- c) All lighting systems shall be controlled via a 24hr programmable timer. The timer shall be supplied inclusive of a bypass switch.
- d) All lighting systems shall include an emergency lighting system that will provide sufficient lighting for the continuous operation of the bus interchange in a PowerGrid failure situation.
- e) The emergency lighting system shall be able to light up critical areas such as the concourse area (interface between the buses and commuters) with an average lighting level of 10 lux for a minimum period of 6 hours.
- f) The lighting shall be at least 10 lux where CCTV coverage is required.

8.3 Lightning Protection System

- a) The lightning protection system to the bus interchange shall comply with SS 555 and SS 551.

- b) Location of earthing pits shall be adjusted to suit site conditions and approval of Authority.
- c) All metal structures shall be bonded to the rebars of the floor slab by means of a purpose made clamp or weld.
- d) The lightning protection system shall be electrically continuous, where the entrance or exit of the bus interchange is connected to any pedestrian underpass, linkway and bus shelters.
- e) The lightning protection system shall be an independent system from any integrated MRT station or development.

8.4 Earthing System and Equipotential Bonding

- a) Earthing requirements shall be provided in accordance to SS 551.
- b) All exposed metal parts shall be equipotentially bonded in accordance to SS CP5.
- c) Earth electrode complete with hot-dipped galvanised lid earth pit haunched in concrete shall be provided to connect to the main earthing terminal in the bus interchange switchboard.

8.5 Water Services, Sanitary Works and Pumped Drainage System

8.5.1 Water Services

- a) The water supply for the development shall comply with PUB Code of Practice for Water Services, CP 48.
- b) The PUB approved type of auto-sensing/electronic sensor flush valves shall be provided for water closets and urinals at public toilets. Flush valves shall be also provided with manual actuation.
- c) Isolation valves shall also be provided at branch off of each area served for maintenance purposes and minimising disruption of water supply.
- d) Common water distribution pipes shall not be routed in tenantable area.

8.5.2 Sanitary Works System

- a) The sanitary works shall comply with PUB Codes of Practice on Sewerage and Sanitary Works.
- b) The drainage from the kitchen area shall be through waste sumps, screen chamber and grease trap before discharging into the inspection chamber.
- c) Sewage ejector system shall be provided for underground bus interchange for the collection and disposal of sewage. All sewage from ground level or above shall be directly discharged to sanitary works system by gravity as far as possible.

8.5.3 Pumped Drainage System

- a) Pumped drainage system shall be provided at the base level of underground bus interchange for the collection and disposal of storm and surface water. The

water shall be positively drained via channels and drains by gravity to the drainage sump. The water shall be pumped to the external storm water drain.

8.6 Passenger Lift (where applicable)

8.6.1 Design Requirements

When lifts are required, they shall be provided to link all levels in the Bus Interchange (BI). The lifts shall be designed in accordance with the requirements as stipulated in clause 11.9 of the Technical Specifications.

8.7 Escalator (where applicable)

8.7.1 Design Requirement

When escalators are required, they shall be provided to link all levels in the Bus Interchange (BI). The escalators shall be designed in accordance with the requirements as stipulated in clause 11.10 of the Technical Specifications.

8.7.2 Automatic Starting and Stopping Operation

- a) The escalator shall operate in two modes: Continuous Operation with Energy Saving (standby speed) and Automatic Start/Stop Operation. The escalator shall be in continuous operation with energy savings (standby speed) between pre-set times e.g. 6am to 12 mid-night. A time switch shall be incorporated in the escalator, which will switch to the automatic start/stop at the other time e.g. 12 mid-night to before 6am. Hence, at 6am, the escalator shall start and resume continuous operation with energy savings (standby speed) after detecting a commuter entering the escalator. The Contractor shall confirm the pre-set times with the Bus Interchange operator.
- b) In addition, photoelectric cells capable of detecting at many various angles, which incorporate a time delay, shall be provided to ensure that nobody is riding on the escalator at the time of the switch-on or switch-off. This shall be subject to the Authority's acceptance.

8.8 Air-Conditioning and Mechanical Ventilation System

8.8.1 General

- a) The section covers the minimum requirements for the design, supply, installation, testing and commissioning of the air-conditioning and mechanical ventilation (ACMV) system for the bus interchange.
- b) The ACMV system for the bus interchange shall comply with the relevant regulations, codes of practice, standards and requirements of the authorities having jurisdiction of the works.
- c) Unless otherwise stated, the design of the air-conditioning system shall be based on the following criteria:
Outdoor Air Condition:

-Dry Bulb temperature: 32°C

-Wet Bulb temperature: 26°C

Indoor Air Condition:

-Design Dry Bulb temperature: 24°C

-Design RH: 60%

- d) The ACMV system for the bus interchange shall be independent from that of the adjacent RTS station or development.
- e) Concourse area of the integrated bus interchange shall be air-conditioned by means of a centralised water-cooled chilled water system with floor-mounted air-handling units (AHUs) housed in the AHU rooms for ease of access for cleaning and maintenance.

The chilled water plant (chiller, pumps and cooling towers) shall have an efficiency of equal or not more than 0.8 kW/RT.

Variable speed drives (VSD) shall be provided for chilled water pumps to save energy. The Building Management System (BMS) shall use the reading from the pressure differential sensors to regulate the speed of the chilled water pumps via the VSDs so that a minimum differential pressure is maintained across the AHUs/ fan coil units (FCUs).

VSDs shall be provided for the cooling towers to save energy. Under normal operating conditions, all cooling towers shall be operating. The BMS shall regulate the speed of the cooling tower fans via the VSDs to ensure that the condenser water supply to the chillers is maintained at a constant temperature.

Condensate water from the AHUs shall be recycled back to the cooling tower basin to save water.

Non- chemical water treatment system shall be provided for the treatment of condenser water piping system, including cooling towers.

Auto-condenser tube cleaning system shall be provided.

- f) All ACMV equipment shall be provided with programmable 24 hours /7 days timer.
- g) Air-curtains shall be provided at the doors of the concourse areas to minimise air exchange between the air-conditioned and non-air-conditioned spaces.
- h) Pre-filters shall be provided for all fresh air intakes of the air-conditioning system. The AHUs shall be provided with primary, secondary filters and UV-C emitters.
- i) A means of emergency switching off the ACMV equipment e.g. mechanical ventilation fans, condenser units, etc. shall be provided adjacent to the equipment when they are located remotely from the MSB, MCC or local control panel from which they take the power supply.
- j) All equipment, components and services installed outdoors or exposed to weather shall be of weatherproof design and resistant to corrosion and ultra-violet (UV).

- k) A weatherproof electrical isolator of appropriate rating shall be provided adjacent to each condensing unit.
- l) All floor-mounted equipment and services shall be mounted on plinths or stumps.
- m) The equipment and services shall be located so that they are concealed from view by the public. The equipment and services shall also not be located where they are accessible to the public and are subject to damage or vandalism. They must be easily access for maintenance without obstructing the operations of the bus interchange.
- n) Openings for outdoor air intakes and exhaust discharge shall be shielded from weather and insects. Outdoor air louvres shall be of weatherproof design and construction. An insect screen constructed of hot dipped galvanised steel wires not larger than 10mm mesh shall be provided behind the louver openings.
- o) Control panels and plantrooms provided for the ACMV equipment shall be lockable. 3 sets of keys shall be provided. The control panels and plantroom shall be adequately ventilated to prevent excessive heat build-up so that the operation of the equipment is not affected.
- p) All plantrooms shall be adequately sized so that there will be sufficient space for proper operation, maintenance and future replacement of the equipment. A water tap, floor trap and weatherproof power point shall be provided in the plantroom for cleaning and maintenance of the equipment.
- q) Sufficient supply air outlets shall be provided to ensure proper air distribution.
- r) Refrigerant for the air-conditioning units shall have ozone depletion potential (ODP) of zero and with a net global potential warming potential (GWP) of less than 2000 over a 100-year time horizon.
- s) All condensate drainpipes for the air-conditioning units(s) shall be concealed and connected to the nearest floor trap. The condensate drainpipes and the floor traps shall be insulated to prevent condensation.
- t) Unless specified otherwise, the ACMV system shall have sufficient redundancy such that in the event of failure of any of the equipment or component, not more than half of the cooling or ventilation requirements of the area served shall be affected.
- u) Unless otherwise specified, the ACMV equipment, materials, installation, testing and commissioning shall also comply with National Productive and Quality Specifications (NPQS), Mechanical Specifications issued by the Building Control Authority.

8.8.2 Ventilation for Bus Parking Area, Driveway and Boarding/Alighting Bay

- a) The bus parking area, driveway and boarding/ alighting bay in the bus interchange shall be naturally cross ventilated to ensure a safe and healthy environment is provided for the passengers, drivers and workers.

- b) For covered bus parking area, driveway and boarding/ alighting bay, engineering analysis by use of computational fluid dynamics (CFD) simulations shall be performed and submitted to demonstrate that the air temperatures and air quality comply with the requirements stipulated below and the authorities having jurisdiction:

Indoor Air Temperature:

- Bus Parking Area : Maximum temperature rise: 5°C above outdoor ambient
- Driveway : Maximum temperature rise: 3°C above outdoor ambient
- Boarding/ Alighting Bay: Maximum temperature rise: 2°C above outdoor ambient

Permissible Concentration Levels of Pollutants:

Pollutants		Averaging time	Concentration
Gaseous Pollutants	Carbon Monoxide	8 hours	29 mg/m ³ (25 ppm)
	Sulphur Dioxide	8 hours	5.2 mg/m ³ (2 ppm)
		15 minutes	13 mg/m ³ (5 ppm)
	Nitrogen Dioxide	8 hours	5.6 mg/m ³ (3 ppm)
		15 minutes	9.4 mg/m ³ (5 ppm)
	Nitric Oxide	8 hours	31 mg/m ³ (25 ppm)
Particulate Pollutants	Respirable Dust Particles	8 hours	5mg/m ³

- c) If natural cross ventilation cannot fulfil the specified air temperatures and air quality requirements, ventilation by a combination of natural and mechanical ventilation may be proposed subject to the Authority's approval. Area served by mechanical ventilation shall incorporate a supply part and an exhaust part with minimum ventilation rate to meet the requirements specified above
- d) Infiltration of contaminated air from the bus parking area, driveway and alighting bay into the concourse area shall be prevented by keeping the concourse area at an overpressure relative to the bus parking area, driveway and alighting bay.
- e) Fire and smoke in the bus parking area, driveway and alighting berth shall not spread into the concourse area and adjacent development.
- f) The ventilation system design shall take into consideration the expected peak number of buses operating in the bus interchange.
- g) Supply outlets shall be located and evenly distributed to maintain areas where passengers are likely to access and transit (e.g. alighting bay), at a lower temperature relative to other areas (e.g. bus parking areas and driveway). The

- supply air shall be drawn directly from the external and its intake shall be more than 5m from any exhaust discharge openings.
- h) Exhaust outlets shall be located at areas where heat and exhaust from buses are expected so that the heat and emission are removed as close to the source as possible. At least 50% of the exhaust air shall be extracted at low level not exceeding 650mm above the finished floor level, as measured from the top of the grille to the finished floor level. Exhaust outlets shall also be located close to the ceiling soffit to minimise the accumulation of heat and pollutants at the ceiling space.
 - i) The discharge points of the exhaust ventilation system shall be arranged to discharge directly to the external. They shall not be less than 5m away from any air circulating and ventilating inlets, openable windows and occupied areas, pedestrian thoroughfares, trafficable areas, areas of public access and exhaust discharges from kitchens. They shall also not face or discharge in the direction of any adjacent residential building.
 - j) When locating the discharge points, the influence of adjacent buildings and prevailing wind direction and the wind distribution over these buildings shall be taken into account. It shall be located away from the downwind of air intakes of the building.
 - k) The exhaust air discharge from the exhaust ventilation system of the bus interchange shall not affect and cause the air quality at the nearest ventilation air inlets and openable windows of the surrounding buildings, pedestrian thoroughfares, trafficable areas and areas of public access to exceed the NEA's ambient air quality guidelines and requirements. An Environmental Impact Assessment (EIA) study shall be carried out to demonstrate compliance with NEA's ambient air quality guidelines and requirements.
 - l) A standby fan shall be provided with capacity equivalent to the largest duty fan.
 - m) For bus parking areas and driveway exceeding one level, the supply and exhaust parts shall be designed in such a way as to minimise intermixing of air between the different levels.
 - n) Upon completion of the installation, site testing and commissioning including air quality and temperature measurements shall be performed to demonstrate that the ventilation system can meet the above requirements.
 - o) Air-monitoring stations comprising of temperature, CO and NO_x/ NO₂ sensors, shall be provided at the covered bus parking area, driveway and boarding/ alighting bay areas to monitor the air quality and to activate the ventilation fans when air quality criteria exceeded. One air monitoring station shall be provided to control each set of supply and exhaust ventilation zone within the covered bus parking area, driveway and boarding/ alighting bay areas.

8.9 Equipment Noise and Vibration

- a) The sound pressure levels due to the operation of the ACMV equipment excluding all extraneous sources shall not exceed the noise levels specified in the Table below.

Table: Maximum Equipment Sound Pressure Level

Location	Maximum Sound Pressure Level
Concourse Area	55 dBA
Bus Parking, Driveway, Boarding and Alighting Berths	65 dBA
Employee Occupied Rooms, Offices	50 dBA
Toilets, Kitchen	55 dBA
Store Room, DB room	65 dBA
<u>Electrical/ Electronic Rooms e.g. Switch Room</u>	<u>75 dBA</u>
<u>Mechanical Plantrooms e.g. Chiller plantroom, AHU Room</u>	85 dBA

- b) The external noise levels shall comply with the NEA's guidelines and requirements.
- c) Acoustic enclosures for fans shall be designed such that it can be dismantled repeatedly for access maintenance of the fans without damper.
- d) All mechanical equipment shall be mounted on vibration isolators in accordance with the manufacturers' recommendation or where necessary to prevent the transmission of vibration and mechanically transmitted sound to the building structure.
- e) Acoustic enclosures for fans shall be designed such that it can be easily dismantled for maintenance access to the fan motors.

8.10 Fire Protection System in Bus Interchange

The provision and design of the Fire Protection System in bus interchange shall comply with all statutory requirements.

8.10.1 Automatic Fire Alarm System

- a) The fire alarm system shall comply with SS CP10. The system shall be connected to a fire station through an approved alarm monitoring company.
- b) The Main Alarm Panel (MAP) shall be easily accessible by Firemen and located in the FCC, if provided. Floor zone chart shall be provided next to the MAP. For bus interchanges integrated with MRT stations, the MAP shall also be able to send and receive summary fire alarm signals to and from the MAPs of the integrated MRT stations via Interfacing Terminal Box (ITB)
- c) Fire-rated roller shutter / swing door (used as fire separation) installed at the boundary adjacent to a development shall be activated by localized smoke detectors installed at both sides of the shutter / door (normally held open). The status of the shutter / door shall be sent to the FCC of the adjacent commercial building and PSC of the MRT Station respectively, where applicable.

8.10.2 Automatic Fire Sprinkler System

- a) The fire sprinkler system shall comply with the requirements of SS CP52 Code of Practice for Automatic Fire Sprinkler System.

- b) For an independent fire sprinkler system, the sprinkler pumps and control panels shall be housed in the sprinkler pump room.
- c) The ladders used shall be aluminium for temporary and stainless steel type for permanent. The hand railings for the ladders shall extend above the tank to facilitate easy access.

8.10.3 Fire Hydrant System

- a) The fire hydrant system shall be provided in accordance to fire code and SS CP29, Code of Practice for Fire Hydrant Systems and Hose Reels

8.10.4 Dry Rising Main

- a) Dry rising main shall be provided for underground bus interchanges.
- b) Dry mains shall be provided in accordance to fire code and SS CP 29 Code of Practice for Fire Hydrant Systems and Hose Reels.

8.10.5 Fire Hosereel System

- a) The fire hosereel system shall be provided in accordance to fire code and SS CP29 Code of Practice for Fire Hydrant Systems and Hose Reels
- b) Wherever possible, the hosereel system shall be fed direct from the PUB mains.

8.10.6 Fire Extinguishers

- a) Fire extinguishers shall be provided in accordance with the Fire Code and SS CP55.




8.11 Building Management System

For integrated bus interchange, PLC-based Building Management System (BMS) shall be provided for centralised monitoring and control of the integrated bus interchange M&E services (Refer to Appendix 2 for typical control and monitoring point schedule for BMS).

8.12 Closed-Circuit Television (CCTV)

- a) CCTV cameras shall be provided to achieve the following:
 - i. 100% coverage for the perimeter of the entire bus bay/bus parking areas at 10%R (where “R” is the abbreviation of “Rotakin”*);
 - ii. 95% general coverage for the bus bay/bus parking areas of the bus interchange at 10%R;
 - iii. 95% general coverage for the concourse area of the bus interchange at 10%R;
 - iv. Coverage of all designated human & vehicular ingress/egress (inclusive of lifts, escalators wherever applicable) at 20% R.
- b) The camera system installed must achieve the following:
 - i. Sufficient recording media to be provided to allow the archival of at least one set of 28 days of recordings an additional minimum buffer of 10%;
 - ii. All video images to be stored at a minimum of 6 frames per second and at a resolution of 4CIF or its equivalent.
- c) CCTV recording facilities shall be provided and housed in a room that shall be designed with adequate reinforcement (protection) to withstand the explosion of a 10kg TNT or equivalent charge (with fragmentations) at a distance of 5 metres away. If this cannot be done, there should be 100% redundancy for the CCTV recording facilities and this redundancy should be housed strategically at a distance no nearer than 30 metres from the primary set of CCTV recording facilities. For both implementation strategies, past video recordings shall be preserved and video recordings shall continue for cameras that are operational in the aftermath of the explosion.
- d) CCTV viewing facilities shall be provided in the Passenger Service Office (PSO), and the number and size of the CCTV monitor screens shall be proposed, in consultation with the Operator, for LTA’s approval.
- e) Uninterrupted Power Supply (UPS) with 1 hour of battery backup shall be provided for the CCTV system.
- f) The bus interchange lighting conditions shall achieve the following:
 - i. Bus interchange’s concourse shall be provided with adequate lighting 24/7 to ensure quality colored images for facilitating investigation and prosecution are captured;
 - ii. Bus interchange’s bus bay shall be provided no lower than 10 lux where CCTV coverage is provided;

* Show an example of what is meant by x% Rotakin using a picture (i.e. a person 1.6m tall fills up x% of the vertical height of the screen)

Percentage	Field of View
Detect 10%	
Observe 25%	
Recognise 50%	
For an example, if the height of the screen is 100cm, the image (test subject measured 1.60m) captured by the camera shall appear on the screen with the height of at least 10cm.	

8.13 One-way and Two-way Emergency Voice Communication Systems

- One-way (or Public Address (PA) system) and two-way emergency voice communication systems shall be provided for the bus interchange as per the Fire Code.
- A PA paging facility shall be provided in the PSO 1 for operation purposes. For bus interchange with FCC, another PA paging facility for the FCC shall be provided in compliance with the Fire Code

9	GUIDELINES ON PUBLIC STREET LIGHTING DESIGN
----------	--

In general, the light fittings for public streets shall comply with SS 263 Part 5.

For major roads and expressways, IP65 high performance lantern mounted on 10 meter pole height with High Pressure Sodium Vapour (HPSV) SON-T Plus lamp shall be used. The minimum distance between each lamp pole required shall range from 45m to 50m, to be determined in accordance to the required performance. The lantern shall be provided with multiple adjustments to have variable light distribution to suit the road conditions. The total light output ratio shall equal or exceed 75%.

10 INTERFACING WITH FACILITIES MANAGEMENT SYSTEM (FMS)**10.1 General**

- a) Where FMS is provided, the developer shall design, supply, install, interface with the existing LTA Facilities Management System (FMS), test and commission and handover the remote (site) end system of the FMS. The remote (site) end system shall consist of the following:
- Interface Terminal Boards (ITBs)
 - Programmable Logic Controllers (PLCs)
 - All cabling between ITBs and PLCs
 - All cabling between equipment monitored and ITBs
 - 1 no. dial up telephone line
 - 2 numbers dial-up modem
 - 2 sets of key switches and indicator lamps for site acknowledgement
 - Enclosure with lock for acknowledgement key switches and indicators
 - 1 number Uninterruptible Power Supply (UPS)
 - All necessary auxiliary devices for monitoring and control equipment
- b) The developer shall be responsible to ensure that the installed remote (end) FMS is able to interface with the existing LTA FMS and shall liaise with the Authority and its appointed Contractor for the interface with the existing LTA FMS.
- c) The developer shall ensure that all equipment and devices to be provided for the FMS remote site shall be able to meet all interface and functional requirements as specified in the Authority's FMS Interface Control and Data Document (ICDD) for future FMS sites.

10.2 FMS Equipment**10.2.1 Programmable Logic Controllers**

- a) The remotesite PLC (Field PLC) shall be housed in a panel with easy access for maintenance work with at least 25% spare panel space for future expansion.
- b) The Field PLC shall be supplied with at least 25% spares including the necessary plug-in modules that are fully configured, wired, terminated, tested and ready for use. In addition to the spares, the PLC design shall include the necessary hardware and software capacity to accommodate at least another 25% for future expansion without degradation in the overall system performance.
- c) The PLC shall be provided with self-diagnostic including communication diagnostics and diagnostics for all panel components.
- d) The main memory of the PLC shall be of solid state type and shall be incorporated for all critical configuration data. Memory backup shall be carried out with lithium battery or equivalent to support the real time clock and all volatile memory for a period of 1 year minimum.

- e) The PLCs shall be capable of supporting at least 512 I/O ports and capable of handling both analogue and digital signals by using different I/O boards.
- f) The digital I/O card of the PLCs shall be designed for fail-safe operation and any single component failure should not cause any malfunction of FMS or control sent. Relays or metallic insulation semi-conductor devices shall be provided to isolate the mains with the electronic device. On-board or on-module indicators showing the status of all I/O points shall be provided.
- g) The analogue I/O card on the PLCs shall have multiple input and output ports of resolution of at least 12 bits. All analogue input ports shall accept full range signals of 4-20mA, 0-5V and 0-10V.
- h) The PLCs to be provided shall be supplied together with its programming software and shall comply to the standards and recommendations of IEC61131 for the programming of the PLC.
- i) The PLC, modems and all its associated devices and components shall come complete with mini UPS backup to prevent momentary power loss. The battery shall have a capacity to support the full rating of the UPS module for a minimum period of 30 minutes at a temperature of 25 degree celsius.
- j) The PLC panel shall be located at a location next to the electrical panels and shall not be accessible to the public.

10.2.2 Field PLC Functional Requirements

- a) The Field PLC shall transmit all E&M equipment, remote site FMS equipment and PLC system alarms real-time. The Field PLC shall also be able to provide the Data Concentrator (PLC at Operation Control Centre (OCC)) with all necessary data as requested during a Data Concentrator communication poll.
- b) The Field PLC shall communicate with the Data Concentrator through a dialup modem. There shall be (2) modems connected to the Field PLC in active and redundancy setup as specified in the ICDD.
- c) The Field PLC shall include a communication port (always available) for connection to the Authority's FMS notebook HMI Client. The interface with the HMI Client notebook shall allow the Field PLC to be able to be programmed to provide the notebook HMI Client with real time visualisation of all data and monitoring points on site.
- d) The Field PLC shall be capable of providing a time-stamp for all data captured or generated before being transmitted to the Data Concentrator.
- e) The interface with the HMI notebook shall include the following functionalities;
 - i) Accept the identification of the user on site that is key-in through the notebook HMI Client for site take-over
 - ii) Field PLC shall send the user's identification and time-stamp of the site takeover request to the Data Concentrator.
 - iii) Field PLC shall be able to accept an acknowledgement from the Data Concentrator on the site takeover request.
 - iv) The Field PLC shall be able to differentiate whether site take over has been granted from the acknowledgement from the Data Concentrator. If site takeover is granted all alarms, events and data logging generated

- during the period of takeover shall not be sent to the Data Concentrator (masked).
- v) The Field PLC shall be able to accept request form the user through the notebook HMI Client to relinquish takeover and acknowledgement by the Data Concentrator that normal monitoring and control of the site can be resumed. The Field PLC shall then unmasked all alarms, events and data logging.
 - f) The remote site FMS panel shall include (2) sets of acknowledgement key switches and indicators. These key switches shall be mounted on the FMS panel if located indoor and mounted on an IP 65 enclosure if located outdoor. The acknowledgement key switches and indicators shall provide the following functionalities;
 - i) Each key switch shall have its own identification and labelled as E&M and Escalator
 - ii) Each key switch shall be connected to the Field PLC digital input module. Upon activation of the key switch, the Field PLC shall send its identification and time-stamped of the activation to the Data Concentrator
 - iii) The Data Concentrator shall then reply with an acknowledgement and the Filed PLC shall turn on its associated indicator through the Field PLC digital output module.
 - iv) Upon deactivation of the key switch, the Field PLC shall send the identification and key switch off message and time-stamped to the Data Concentrator which shall then reply with acknowledgement and the indicator shall be turn-off.

10.2.3 Cabling and Wire Terminations

- a) Soderless and screwless techniques shall be the preferred means of terminating conductors. Crimping or other standard industry practice may also be used.
- b) All wire and cable terminals shall be properly numbered and labelled with descriptions of their functional purpose.

10.2.4 Telephone Line

- a) The property owners shall apply for the telephone line and bear all telephone line charges prior to handing over of the FMS to the Authority. The telephone line shall be transferred to the Authority. Upon issuance of the Certificate of Statutory Completion (CSC) or end of Defects Liability Period (DLP) and handover of the FMS to the Authority.
- b) The location of the telephone terminal box shall be next to the FMS panel.

10.2.5 Auxiliary Devices

The developer shall be responsible for all design, supply, installation, testing and commissioning of auxiliary devices for FMS monitoring and control purposes to the respective equipment to be monitored. The auxiliary devices shall include but not be limited to the following:

10.2.6 Equipment Status Monitoring

Equipment status monitoring point shall be in the form of voltage free, normally open contacts. All signals sent by any monitoring point shall be latched in order to ensure that the signal is able to be received by LTA FMS. All equipment status monitoring point must be electrically isolated from power circuits.

10.2.7 Level Switches

Level switches shall be of magnetic type or other approved non-electrical type, for sensing of low liquid level in the tank. Switch shall have the snap action SPDT type contacts rated at 1.2/230V AC.

10.2.8 Current Transformers and Voltage And Current Transducers

Voltage transducer shall have an output of between 4 to 20 mA. Current transformers shall have a secondary output of between 0 to 5A and current transducers shall have an output of between 4 to 20 mA.

10.2.9 Wiring

- a) All wiring for FMS interfacing shall be as follows:
 - Digital Input (DI), Digital Output (DO), Digital Alarm (DA) : 0.6mm diameter, single, twisted pair screen signal cable
 - Analog Input (AI), Analog Output (AO) : 0.9 diameter, duo twisted pair screen signal cable
- b) All cable screens for DI and AO shall be left floating at the equipment (auxiliary contacts, sensors etc.) and shall be terminated in a common screen terminal on the terminal block.

10.3 Schedule of Points

The FMS points to be monitored are as follows:

Fire protection system	DA	General Alarm
	DA	General Fault Alarm
	DA	Fire Shutter Close
Lighting	DA	Main Outgoing MCB Trip Alarm for each group of lighting circuit. (For underpass only)
Fan / Air conditioner	DI	Power Supply Status
	DO	On/Off Control
	DI	On / Off Status
	DA	Trip Alarm
Air-curtain	DI	On/Off Status

	DA	Trip Alarm
Pumps	DI	Power Supply Status
	DI	On/Off Status for each pumps
	DA	Trip Alarm for each pumps
	DA	High Level Alarm (2 levels for Vehicular Underpasses and 1 level for Pedestrian Underpasses)
	DA	Low level Alarm.
LES Message Display Sign	DO	Message Control
	DI	Power Status
Escalators	DI	Power Supply Status
	DI	Up Direction Status
	DI	Down Direction Status
	DI	Maintenance Mode
	DA	Trip(fault) for safety switches
	DA	Escalator Running/Stop
	DA	EBOPS Battery fault status, if applicable
	DA	Emergency Stop for push button
Lifts	DI	Power Supply Status
	DI	On/Off Status
	DI	Lift Maintenance mode
	DI	Lift Parking Control mode (if applicable)
	DA	Emergency operation (Fire operation)
	DA	Lift Common Trip
	DA	Power Failure Operation (ARD or Genset operation)
	DA	Lift pit flood Trip
	DA	Lift car home
	DA	EBOPS Battery fault status
	DA	ARD Battery fault status
Generators	DI	Power Supply Status
	DA	Genset Failure Alarm.
	DA	Battery Charger Failure
	DA	Low Fuel Tank Alarm
	DA	Genset Running Alarm

11 TECHNICAL SPECIFICATIONS

11.1 Code and Regulation

In addition to local requirements, equipment and system design shall also comply with the following codes of practice and standards:

- British Standards (BS)
- International Electrotechnical Commission (IEC)
- International Standards Organization (ISO)
- ASHRAE – American Society of Heating, Refrigerating and Air-Conditioning Engineers
- Guidelines for Good Indoor Air Quality in Office Premises
- AMCA - Air Movement and Control Association (USA)
- ANSI - American National Standards Institute (USA)
- ARI - Air-conditioning & Refrigeration Institute
- ASTM - American Society of Testing and Materials
- HVCA - Heating and Ventilation Contractors Association (UK)
- SMACNA - Sheet Metal and Air-conditioning Contractors' National Association Inc. (USA)
- UL - Underwriters Laboratory

11.2 LV Power Systems

11.2.1 LV Main Switchboard**11.2.1.1 Particular Requirements**

- a) The LV metal clad main switchboard shall be of Form 4, floor standing and type-tested assembly (TTA) as defined in IEC 61439-1: Part 1 for integrated Bus Interchange. For standalone Bus Interchange rated at 400A and below, the switch board shall be Form 3.
- b) The main switchboards shall be vermin proof with ventilation louvers complete with insect netting at the back and sides of the switchboards and the finished assembly shall conform to IP 42 in accordance with IEC 60529. Anti-condensation heaters with indication lamps shall be provided in each compartment. The anti-condensation heating elements shall be suitable for connection to the main electricity supply (230V AC). The heater shall be thermostatically controlled and easily accessible for maintenance replacement.
- c) Incoming circuit breakers shall be provided with the capability of being padlocked in the "OFF" position.
- d) 20% spare panel space shall be provided for future expansion purposes. Busbars shall be extended as necessary and drilled for future connection of conductors.

- e) As-built line diagram, control circuit and layout plan shall be inserted in a permanent pocket on the inner side of the panel door of each switchboard. All diagrams must be endorsed by LEW of the appropriate grade.
- f) The Contractor shall provide the following in the LV Switchrooms
 - i. Rubber mats of at least 5mm thick and 600mm wide shall be provided for the entire length in front of all floor mounted switchboards.
 - ii. Statutory safety notices, regulations and instruction for resuscitation and treatment after electrical shock.
 - iii. Danger signs in 4 languages displayed on switchboards / control panels / doors for electrical rooms complying with the requirements of the Energy Market Authority.
 - iv. Suitable metal cabinet (A2 size) for writing purposes, installed next to the framed single-line drawing.
 - v. Key cabinets with sufficient capacity for the number of keys required for padlocking all circuit breakers and all the keys for control switches on the entire LV main switchboards.
 - vi. A4 size log-book for recording of all access to and activities in the LV Switchroom.

11.2.1.2 Busbars and Supports

- a) Busbars shall be made of hard drawn, electro-tinned high conductivity, bare rectangular solid copper bars complying with BS EN 13601. Full size phase and neutral busbars shall be provided.
- b) The busbar shall be colour code in compliance to latest CP5 for phase identification. Phase identification label shall totally wrap non-adhesive heat shrinkable type around the busbars.
- c) The minimum busbar clearance between phases and between phases and earth shall be in conformance to BS 159.
- d) Busbar shall be constructed in such manner so as to allow for future extension without dismantling and modifying of the busbars and busbar mounting. Busbar shall run throughout the entire length of the switchboard.

11.2.1.3 Protective Relays

Protective relays shall be manual reset type with flag indication of tripping complying with IEC 60255.

Relay	Type	Setting Range
Overcurrent	DTL, normal 3/10 or 1.3/10 to IEC 60255-22-1	50% to 200% of rated values with instantaneous high set elements
Earth Fault	DTL, normal 3/10 to IEC 60255-22-1	10% to 40% of rated values

11.2.1.4 Current Transformers (CT)

- a) CTs shall comply with BS EN 60044-1 and shall be rated for Class B temperature rise.
- b) CTs shall be epoxy resin encapsulated type and shall be capable of providing the necessary output to operate the connected protective devices or instruments.
- c) Terminal of each set of CT shall be earthed through a removable link.
- d) Protection CTs shall be suitably rated and have Class 5P accuracy or better. The product of rated accuracy limit factor and rated output of the protection CT shall not be less than ten (10) times the rated burden of the trip circuit including the relays, connection leads and overcurrent release where applicable.

11.2.1.5 Indicating Instruments

- a) All analogue indicating meters shall have a frame size of approximately 96mm x 96mm with a scale arc of approximately 240°. The range selected shall be suitable for the voltage and current levels to be indicated, with mechanical zero adjustment accessible from the front without dismantling the instruments. In addition to instantaneous indicators, ammeters shall be provided with half-hour maximum demand indicator.
- b) All analogue indicating meters shall comply with IEC 60051-1, of the moving iron spring controlled type. The accuracy class shall be 1.5 for indicating instruments and 2 for integrating meters.
- c) All indicating instruments shall not be damaged by occurrence of a short-circuit or over-voltage which can be withstood by the switchgear.

11.2.1.6 Indicating Lamps, Push Buttons, Selector and Control Switches

- a) All indicating lamps, luminous push buttons shall be of LED type. The indicating lamps shall be designed to permit removal of lamp lenses and LED from the front of the units without the need of any special tool and opening of the panel doors.
- b) All indicating lamps which are connected to mains voltage shall be equipped with built-in double wound transformer. Lamp lenses shall be clear type with appropriate colour coding band.
- c) Selector switches for ammeters shall be of the rotary type with make-before-break contacts for selection to read the three phase currents, with the necessary engraved plates with L1, L2, and L3 clearly indicated.
- d) Selector switches for voltmeters shall be of the rotary type with 'break-before-make' contacts for selection to read the line voltages and phase voltages, with necessary engraved plates with L1, L2, L3, L1-L2, L2-L3, L3-L1 clearly indicated.

11.2.1.7 Fuse Link

- a) All equipment shall be fitted with suitably rated fuses. All control and monitoring circuits eg. heaters, indications, alarms, measuring instruments, etc. shall be provided with fuse.
- b) Fuses shall be of the non-rewirable cartridge type. Fuse carriers and bases shall be made from high grade flame retardant non-hygroscopic moulding, with high

resistance to tracking. Fuse bases shall have solid non-distortable fixed contacts, fully shrouded contacts and terminals to IP20 with fuse carrier removed. Fuse carriers shall be fully skirted to IP20.

- c) All fuse links shall be properly labelled to identify the rating.

11.2.1.8 Panel Heaters

- a) Each section of the MSB shall be fitted with a panel heater operated on main supply and rated at not less than 60W per 1.5cu.m volume. The heaters shall be shrouded and mounted at the bottom of the switchboard.
- b) The heaters shall be individually fused and fitted with rotary ON/OFF selector switch, thermostatic controls and a lamp to indicate the energisation of the heaters at the front.

11.2.1.9 Earthing

- a) A tinned copper earth bar complying with SS551 and SS CP5 shall be provided along the whole length of the switchboard.

11.2.1.10 Labelling

- a) All labels shall be manufactured from laminated traffolyte or similar plastic materials, engraved and fixed by stainless steel screws.

11.2.1.11 Internal and Control Wiring

- a) All internal and control wiring shall be 600V/1000V grade PVC insulated Copper cable to IEC 60228 Class 2.
- b) Each wire shall be fitted at both ends with a white ferrule and black engraved inscription to correspond with the connection diagram.

11.2.2 LV Distribution Board (DB)

11.2.2.1 General

- a) DBs shall be of metal enclosed, factory built type corresponding IEC-Recommendations No. 61439, 60144 and 60157.
- b) Each DB is to be labelled properly with reverse engraved name plate secured by stainless steel screws. The details of the labels are to be approved by the Authority before fabrication.
- c) 20% spare outgoing circuit breakers shall be provided future expansion purposes.
- d) 20% spare panel space shall be provided.

11.2.2.2 Panel Construction

- a) The DB enclosure (panels/doors) shall be made of electro-galvanised steel sheets (minimum thickness 2 mm) and finished with epoxy powder coating (minimum 60 micron) colour to the acceptance.

- b) The enclosure shall be completed with hinged doors and to be provided with standardised key lock and 3 sets of key.
- c) The distribution board shall be composed from standardised items, enabling easy exchange or replacement of faulty equipment.
- d) The distribution board shall be supplied to minimum IP 44. In areas where the distribution board is exposed to weather, the distribution board shall be to a minimum IP 54. Proper four language warning signs indicating danger and voltage level shall be provided.
- e) Each distribution board shall be supplied complete with top/bottom removable metal plates for cable entry and exit.
- f) Unless otherwise approved, access to the boards shall be from the front, the doors shall be furnished with lift off hinges to permit an opening enabling an unrestricted access to the board interior. All doors and covers shall be fitted with moulded gaskets of non-ageing material.
- g) The board interior apparatus shall be fixed mounted on back plates of reinforced steel for rigid support and covered with a transparent front panel making the access to the live parts impossible. The circuit breakers shall be mounted such that the above-mentioned front panel need not be removed in order to operate any breakers. The meters and indication lights shall be installed in the door openings and be visible without opening the door.
- h) The distribution boards shall be provided with tinned copper conductor busbars rated for the appropriate continuous current and short circuit current.
- i) Each distribution board shall also be furnished with neutral and earthing busbars having the same rating as the phase buses.
- j) Each distribution board shall be fitted with a multi-terminal earth bar with one terminal for each outgoing circuit. Connection to this earth bar shall be direct without dependence on exposed conductive parts of the enclosure and shall reflect the circuits served, i.e. Circuit no. 1 in terminal no. 1 etc.
- k) Each distribution board shall be fitted with a multi-terminal neutral bar with one terminal for each outgoing circuit. Connection to this neutral bar shall be direct without dependence on exposed conductive parts of the enclosure and shall reflect the circuits served, i.e. Circuit no. 1 in terminal no. 1 etc.
- l) Each distribution board shall be fitted with an earth stud located in an accessible position on the inside of the board. All metal parts of the board except current carrying parts shall be bonded together electrically and to the earth bar.
- m) The construction of the distribution boards shall be such that no cable is subjected to bend of internal radius less than four times the overall diameter of the cable.
- n) As-built line diagram, control circuit and layout plan shall be inserted in a permanent pocket on the inner side of the panel door of each distribution board. All diagrams must be endorsed by LEW of the appropriate grade.

11.2.3 Overground (OG) Box

- a) The OG box shall be outdoor type. All components of the OG box shall be accommodated in a weatherproof housing complying to IP 54 and of robust construction.

- b) The housing shall be made of aluminum alloy with thickness of not less than 2.5mm. The OG box shall be spray with 1 coat of anti-rust primer and 2 finishing coats of paint. Colour of OG box to be accepted by Authority.
- c) Adequate ventilation shall be provided to permit natural circulation of air. The ventilation apertures shall be suitably screened to prevent the entry of vermin and other foreign bodies.
- d) The OG box shall be provided with a root of ample strength and suitable for mounting on a concrete/brick footing. A concrete plinth of minimum height of 400mm shall be provided for mounting of the OG box.
- e) Hinged door complete with standardised lockset shall be provided at the front of the OG box. The door locks and keys for all the distribution boxes shall be similar and interchangeable. 3 sets of keys shall be provided for each OG box.
- f) 20% spare panel space shall be provided.

11.2.4 Switchgear, Apparatus and Internal Wiring

11.2.4.1 Moulded Case Circuit Breakers (MCCBs)

- a) MCCBs shall comply with IEC 60947-2 Part 2, short-circuit performance utilisation category B and shall have all mechanical and live metallic components completely enclosed within an all insulating moulded case.
- b) MCCB shall have over-current tripping mechanism of the thermal magnetic, temperature compensated type to give time delay overload circuit protection and instantaneous short-circuit interruption. The operating characteristic shall be such that the time delay on overload tripping is inversely proportional to the overcurrent up to a threshold value of approximately seven times the rated current at 40°C.
- c) MCCB shall be provided with a shunt trip. The shunt trip unit shall be controlled by an earth fault current sensing device and static electronic circuitry providing an adjustable earth leakage tripping range between 1 to 5A and an adjustable tripping time of 0 to 5 seconds. An indicating lamp with lamp test and reset buttons shall also be provided to indicate MCCB tripped status on earth fault.

11.2.4.2 Miniature Circuit Breakers

- a) Miniature Circuit Breakers (MCBs) shall comply with IEC 60947-2. It shall be single-phase, air-break type equipped for manual control and with automatic overcurrent trip-free mechanism (bimetal device for overload-protection and electromagnetic device for short-circuit instantaneous tripping).
- b) A minimum breaking capacity, corresponding to the busbar fault-level indicated on the drawings/or specification shall be guaranteed.

11.2.4.3 Residual Current Circuit Breaker

- a) Residual Current Circuit Breaker (RCCBs) shall be of PSB approved type and manufactured to SS 97 or IEC 61008-1.

11.2.4.4 Programmable Timers

- a) Timer input voltage shall be powered by AC 100- 240VAC (+10%/-15%, 50Hz)
- b) The timer shall conform to:
 - Noise Immunity : IEC6100-4-4, 2 kV (power supply line).
 - Ambient operating temperature: 0 to 55 °C
 - Humidity : 10% - 100%
- c) The Timer shall have the following programmable features:
 - Programmable: With input and output conditions per line.
 - Basic CPU Input/ Output: Min 3 inputs and 3 outputs
- d) All outputs should have a relay switching capacity of 5A at 240VAC with independent common.
- e) The Timer Central Processing Unit (CPU) shall be provided with built-in real-time clock and calendar functions. The real time clock should have an accuracy of +/- 6 mins max. per year. The data of real time clock, calendar, holding bits, holding timers and counter present value shall be held by a non-battery system for a minimum of 48 hours for prolonged power interruptions.
- f) The Timer program and system setting data shall be stored in internal EEPROM to prevent loss of setting/program during power failure.
- g) The Timer shall have the following features and functions:
 - Front panel LCD display with backlight. Backlight can be automatically cut-off through adjustable settings to save the lifespan of backlight.
 - Input filters settings to prevent noise-related malfunctions such as false triggering of inputs.
 - Password protection function to prevent unauthorized modification of Timer programs and settings.
- h) The Timer shall provide RS232C communication port or infrared port for downloading of program and setting.
- i) The Timer shall support communications via RS232C to host devices such as computers and Personal Digital Assistant (PDA).
- j) The Timer system shall be equipped with the Windows Based software programming tools and drivers for the set-up of communication between Timer and host devices.
- k) The Timer shall be provided with application software tool running on Windows CE powered PDAs to allow setting of programs and the download/upload of the settings.
- l) All Timer technical details and full communication protocols shall be provided.
- m) The Timer shall have self-diagnostic functions and shall be displayed on the CPU LCD. All errors shall be communicated back to host via the RS232C communication port or infrared port.
- n) Factory test certificates shall be submitted to the Authority for verification.
- o) For bus interchange, simply timer shall be used.

11.2.4.5 Contactors

- a) Contactors shall comply with IEC 60947-4 and of suitable rating. They shall be provided with main contacts capable of at least 105 switching operations and at least two auxiliary contacts for remote control (230V, AC). Contactors for lighting control shall be of Utilisation Category AC1, Class 3.

11.2.4.6 Power Supply Company's Meter board

- a) Power Supply Company's meter board shall be installed for each OG Box in accordance with the requirements of the "Handbook on application for electricity supply". There shall be one-meter board for each OG Box as shown on the drawings.
- b) All arrangement for installation of the Power Supply Company's meter, application for supply turn-on including liaison, co-ordination and obtaining power supply company's approval for all the meter boards shall be included as part of the work. All fees and charges incurred shall be deemed to be included in the tender offer.

11.2.4.7 Internal Wiring

- a) All internal wiring in each item of equipment shall be installed in wiring channels or conduits as far as possible. Exposed wiring shall be kept to a minimum but where necessary the wires shall be formed into compact groups suitably bound together and properly supported. Non-metallic materials are preferable for the channels or conduits.
- b) All conductors shall be terminated with suitable pressure type terminal lugs or proper sizes for terminal studs at the terminals blocks or shall be terminated in a manner compatible to the terminals of the instruments.
- c) All conductors shall run continuously between terminal studs without splices or taps.
- d) All conductors shall be labelled at each termination with wire number as designated on the circuit diagrams.
- e) All internal wiring conductors shall be stranded copper wire, not less than 450/750 V class PVC insulation.
- f) Conductor colour coding shall be as per the latest edition of SS CP 5.

11.2.4.8 Surge Protection Devices (SPD)

- a) Lightning Surge Arrester (LSA) shall be of Type 2, DIN-rail type with standard 8/20 wave characteristics complying to IEC 61643-1 or DIN EN 61643-11.
- b) LSA shall have a discharge rating of minimum 40kA and protected by appropriately rated and dedicated miniature circuit breakers that have been tested to coordinate with the manufacturer's SPDs in accordance to IEC 60364.
- c) LSA shall be reusable type and have the choice of a LED indicator or mechanical indicator for end of life.
- d) LSA shall be designed for common mode protection.

11.2.5 LV Cables

11.2.5.1 PVC/PVC and PVC Cable

- a) PVC/PVC cables & PVC cables shall be 600/1000 volt and 450/750 volt grade respectively consisting of high conductivity copper wire.
- b) The cables shall be manufactured to SS 358-3 / BS 6004

11.2.5.2 PVC/SWA/PVC Cable

- a) Cables of this type shall be 600/1000 V grade consisting of high conductivity copper wire, insulated and sheathed with polyvinyl chloride. Cable of this type shall be manufactured to IEC 60502.
- b) PVC insulated cores shall be sheathed with PVC, which shall serve as bedding for galvanised single steel wire armouring. The nominal diameter of the wire armour shall not be less than 1.6 mm. All armour cable shall be terminated using a proper gland.

11.2.5.3 Cable Installation

- a) All cables shall be adequately protected against risk of mechanical damage to which they may be liable in normal conditions of service.
- b) All cables shall be provided with identification labels at each end.
- c) Cable joints and splices shall be prohibited.
- d) Where cables pass through holes in metalwork, precautions shall be taken to prevent abrasion of the cables on any sharp edges.
- e) Where appropriate, final connections to fixed equipment shall be by means of cables in flexible conduits.
- f) All electrical wirings shall comply with new cable colour code.

11.2.6 Ancillary Equipment

11.2.6.1 Switches

- a) Switches shall be of the quick make, slow break type with silent, totally enclosed switch action and solid silver alloy contacts. Switched socket outlets for indoor use shall be housed in suitable galvanised steel boxes to BS 4662 with conduit knockouts.
- b) All switches associated with essential supplies shall be provided with red rocker switches.

11.2.6.2 Switch Socket Outlets

- a) Switched socket outlets shall be single pole (13 Amp), 3 rectangular pin switch shuttered outlets, either surface or flush mounting according to location. All switched socket outlets shall be EMA approved type and tested by accredited testing body and each shall have a safety mark sticker.

- b) Switches shall be of the quick make, slow break type with silent, totally enclosed switch action and solid silver alloy contacts. Switched socket outlets for indoor use shall be housed in suitable galvanised steel boxes to BS 4662 with conduit knockouts.
- c) 15 ampere switched socket outlets shall be 3 pin round type to BS 546 shuttered, of a finish similar to 13 ampere switched socket outlets and mounted in flush steel conduit boxes.
- d) Switched socket outlets in all mechanical plant rooms, electrical sub-stations and switch rooms shall be of the metal-clad type.
- e) 15-ampere weatherproof socket outlets shall be of 3-pin type. Earth terminal shall be provided inside the socket outlet.

11.2.6.3 Isolators

- a) Isolators shall be of either double pole or four poles with current ratings fit for the purpose and shall be enclosed, metal-clad with positive quick-make and quick-break action. Padlock facility shall be provided such that the isolator shall be locked in the position.
- b) Isolators shall be capable of passing and also interrupting their full rated current safely and without damage. Ferrous materials shall be galvanised, switch handles shall be interlocked to prevent opening the over with the switch "ON".

11.2.6.4 Fused Connection Unit

- a) Fused connection unit shall be single pole (13 Amp), unswitched type, either with or without neon indicator and cable outlet. All fused connection unit shall be EMA approved type and tested by accredited testing body and each shall have a safety mark sticker.
- b) Fused connection unit for indoor use shall be housed in suitable galvanised steel boxes to BS 4662 with conduit knockouts.
- c) 15 ampere fused connection unit shall be of a finish similar to 13 ampere switched socket outlets and mounted in flush steel conduit boxes.
- d) All fused connection unit in all mechanical plant rooms, electrical sub-stations and switch rooms shall be of the metal-clad type.

11.3 Lighting Fixtures and Installation

11.3.1 General

- a) All components within the luminaries shall preferably be from the same manufacturer to ensure compatibility. All similar items of equipment shall be interchangeable.
- b) Unless otherwise specified, all luminaries offered shall be as per manufacturer's standard, except that all luminaries shall be modified, if not already catered for, to accept conduit termination, without affecting the quality of the product.
- c) All fittings shall be corrected to a power factor of not less than 0.8 lagging individually.

- d) All fittings shall be supplied complete with control gear, lamps etc.

11.3.2 Types of Lamps

11.3.2.1 Fluorescent Lamps

- a) Fluorescent Tubes
- T5 fluorescent tubes shall be manufactured complying to BS EN 60081 with bi-pin lamp cap. High efficacy tubes (minimum 86 lumens per watt) shall be used.
 - The guaranteed minimum life expectancy of the lamp shall be 5,000 hours.
- b) Fluorescent Lamps control gears
- Ballast for the fluorescent fittings shall be electronic ballast type.
 - i) The electronic ballast shall be designed to operate at 50Hz nominal frequency and at nominal voltages indicated on the label, 220-240V, 50-60Hz.
 - ii) The electronic ballast shall operate at frequency higher than 41kHz to avoid any interruption with other electrical component operating at a lower frequency.
 - iii) The electronic ballast shall comply to the following standard and requirements:
 - Performance requirement : IEC 60929 & 60928
 - Harmonics requirement : IEC 61000-3-2
 - Radio frequency interference : CISPR 15, ad 7.1 / EN55015
 - Immunity to interference : EN 61547
 - iv) The electronic ballast must have the CE, ENEC or EEI indication.
 - v) The power factor should be greater than 0.97.
 - vi) The design life of the electronic ballast shall be 50,000 hours at measuring point temperature (Tc) of 70 Degree Celsius.
 - vii) The failure rate of the ballast should be less than 0.2% per 1000 hours of operation.
 - Starters shall be of self resettable electronic type complete with radio interference suppression capacitor.
 - Power factor corrections capacitors shall comply with BS EN 61048, BS EN 61049 and fitted with quick connect terminals in lieu of leads. One capacitor in each fluorescent fitting to correct power factor to 0.85 lagging shall be provided.

11.3.2.2 High Pressure Discharge Lamp

- a) High Pressure Sodium Vapour Lamp
- The high-pressure sodium vapour lamp shall be ellipsoidal in shape (except for SON/T which shall be tubular in shape) and shall be fitted with standard E40 nickel-plated cap (except for 70W SON which shall have a E27 cap) and suitable for use on 230V mains supply. The lamp shall have a minimum efficacy of 90 lm/watt. The colour temperature shall be 2100°K.

- The start-up time for the lamp to start from cold to reach its 80% of full light output shall be within 3 to 4 minutes. And the maximum restrike time of the lamp shall not exceed 1 minute.
 - The guaranteed minimum life expectancy of the lamp shall be 10,000 hours.
- b) High Pressure lamp control gears
- Lamp control gears (ballasts, igniters, capacitors) of the high-pressure lamp shall be designed to reliably start and operate the lamp in the ambient conditions and within the limit specified by the lamp manufacturer.
 - Ballast shall be auto-regulator; precision wound type, with high power factor and shall have a guaranteed life of 10 years. The ballast shall be tropicalised and encapsulated in non-melt resin (155°C) to ensure maximum protection from moisture and corrosion. The noise level shall be less than 30dBA at a distance of 1 meter. All ballasts shall reliably operate the high-pressure lamps at mains voltage of 200V to 245V.
 - Ballast temperature shall not exceed the maximum permissible operating temperature of the ballast insulating materials. Ballast with known cooler temperature will be preferred. Ballast offered shall be the low loss type.
 - Power factor of the lamp circuit shall be maintained above 0.85 lagging. Power correcting capacitor shall comply with SS123 and BS EN 61048, BS EN 61049 and shall be metallised polypropylene type.
 - Electronic igniters shall be totally enclosed type. It shall ensure quick start-up and quick restrike of the high-pressure lamp. The ignitron shall have the ability to sense a failed lamp and switch off to avoid high voltage stress and high current on the ballast and avoid creating radio interference.

11.3.2.3 Light Emitting Diode (LED) Luminaire

a) General

- i) The LED luminaire, including the LED's, its associated electronic control gears (Driver) and all accessories, shall be designed to fully withstand the current voltage surges of lightning strikes and the frequent switching operation of the power supplies.
- ii) Each luminaire shall consist of 2 main components consisting of an independent LED Module and Electronic Control Gear (driver).
- iii) The driver and LED module shall be integrated into the luminaire. The driver shall be designed to be replaceable with standard compatible driver.
- iv) The luminaire shall be of robust constructions which combine excellent functional and visual design. The luminaire shall be of dustproof and jetproof to IP65, vandalproof and shall be completed powder coated finishing.
- v) The luminaire shall be two feet long and the main components shall be easily replaceable without removing the whole light fitting. Four feet luminaire can be considered subject to approval.
- vi) Test reports shall be submitted from local or international Accredited Test Labs for approval.

b) Performance Requirement

- Luminaires
 - i) Operation of LED Life Span – The rated LED life should be more than 50,000 hours at ambient temperature of 35 °C or higher.
 - ii) System power shall not exceed 11W.
 - iii) Lumen Output shall be 600 lumens or better.
 - iv) The luminaire shall comply with the requirements of safety extra-low voltage (SELV) system.
 - v) The luminaire design shall be tested to relevant local or international standards and including the following:

IEC 62031	LED module for general lighting – Safety Specification
IEC 60598-1	Luminaire – General requirements and test
IEC 62384	DC or AC supplied electronic control gear for LED modules – Performance requirements
IEC 61347 Part 1 and Part 2-13	Particular requirements for d.c or a.c supplied electronic control gear for LED modules.
LM 79	Approved method: electrical and photometric measurements of solid-state lighting products
LM 80	Approved Method: measuring lumen maintenance of LED light sources.

- LED Module

The LED module shall have the following information distinctly and durably marked:

- i) Trademark or mark of origin (Brand & model of LED used)
- ii) Nominal Wattage
- iii) Correlated Colour Temperature (CCT)
- iv) Colour Rendering Index
- v) Weight
- vi) Marking requirements in accordance to relevant local or international standards.

The LED Module shall have the following features:

- i) Heat sink with high thermal dissipation properties
- ii) Provisions to prevent unauthorized removal.
- iii) Corrosion resistant.
- iv) Diffuser shall be UV coated

- v) Operate in relative humidity of greater than 90%

The LED luminaire shall be provided with adequate thermal performance for the long term operation of the LED's at an ambient operating temperature of not less than 35 °C in accordance to relevant local or international standards. The LED junction temperature shall be maintained at or below manufacturer's recommendation.

The rated LED life L70/B50 shall be more than 50,000 hours at LED operating at 35 °C.

- Electronic Control Gear (Driver)

- i) The selected driver shall comply with the requirements of safety extra-low voltage (SELV) systems.
 ii) The selected driver shall satisfy the following requirements:-

Life Span	50,000 hours of operations at max. case temperature of 70 °C or higher
Power factor	0.9 or better
Rated input voltage	AC 230 +/- 10 V, 50Hz

- iii) The electronic control gears shall power the LED such that the LED is flicker-free and it shall be suitable for Class 1 luminaires.

- Lamp Holder

- i) Lamp holder shall be universal holder type.
 ii) The material of lamp holder shall be ensured that is tested to relevant local or international standards.

- Accessories

- i) LED Module / Driver – DC Cable Coordinator and Internal Wiring
 ii) LED module connector shall be 3.5mm diameter. (Female)
 iii) Driver module connector shall be 1.3mm diameter (male)
 iv) The cable length for each module shall be at least 150mm and shall be compatible with the prescribed DC cable connector.
 v) DC cable connector shall be rated at IP 67.

11.3.3 Types of Light Fixtures

11.3.3.1 Recessed Fittings

Recessed luminaires shall be IP20 and shall come with stepped mirror louvre. Body shall be sheet steel, high grade with stove enamel finish. Parabolic mirror louvre shall be aluminium louvre with V shaped longitudinal vanes and stepped

transverse vanes made of chemical brightened and anodised aluminium. Exceptional precise thickness of transverse vanes minimum 2.3mm in light control, high visual comfort with a minimum of glare. Additional parabolic mirror behind the lamps to ensure light output ratio to be greater than 0.8. Electrical connections shall come with cable entry via grommets, all wiring using heat resistant (105°C) cable. The fitting shall be complete with aluminium trimming. The luminaries shall be of open construction for ventilation. The luminaries shall allow for easy relamping.

11.3.3.2 Recessed Down lighter

The recessed down lighter shall be complete with silver reflector, white trim procelain ES lamp holder with adjustable mounting clips, prewired to junction box cable clamp for incoming cables and black baffle, and complete with energy saving compact fluorescent lamp.

11.3.3.3 Dust & Jet proof Fitting

The dust & jet proof fitting shall be of robust construction, which combine excellent functional and visual design. Dustproof and jet proof to IP65 and vandal proof, designed to IK06. The housing shall be moulded in matt glass fibre reinforced pressed polyester. The sealing gasket of the diffuser shall be foam filled flange type and the fitting shall be provided with a watertight cable entry gland. The reflector shall be white enamelled steel reflector, zinc plated on rear where electrical control gears are mounted. The diffuser shall be injection-moulded acrylic with internal prising and sharp rim for excellent seal and UV stabilised.

11.3.3.4 Street Lighting Poles and Lanterns

a) Technical standards for lantern

- Lanterns shall be suitable for use on a supply voltage of 230 Volt, +/- 6 % 50 Hertz.
- The lantern shall comply with and be tested to the requirements of IEC 60598-2-3 or equivalent.
- The lantern shall be classified for protection against electric shock as class I or Class II and the degrees of protection for lamp compartment and gear compartment shall be at least IP 65 and IP 43 respectively.
- A separate terminal for the connection of an earth continuity conductor, clearly and indelibly marked shall be provided. All exposed metal parts and other parts accessible when the lantern 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.
- The lantern 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. The wiring used shall be heat resistant type with the temperature rating marked on the insulation.
- A readily accessible barrier terminal block with the 'live' and neutral' connections clearly and indelibly marked for the connection of incoming

supply cables shall be provided as close as possible to the point of entry of the supply cables.

- A means of clamping the electrical supply cables shall be provided in the lantern to relieve the termination of strain. The cable clamp arrangement shall not damage the insulation of the cables.

b) Technical Standards for Lighting Pole

- The poles shall be designed to withstand a wind speed of 27 m/sec (60mph).
- Weatherproof door shall be provided with a locking device over the door opening of each pole. The triangular locking device shall be made of stainless steel. 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.
- A stainless steel chain of suitable length is to be welded on both the inside of the pole door and the pole. This is to prevent the loss of poles door.
- The door opening shall be flush with the poles. The gap between the pole and the pole's door shall be small and even all round. The rain shelter can be eliminated provided assurance can be given to the Electricity Utilities Agencies Licensee that rain water will not enter the poles and the termination kit.
- An aluminium nameplate of size 50mm x 75mm shall be installed on the outer surface of the poles doors. The following details shall be engraved on the plate:-
 - Name of Manufacturer
 - Year of Manufacturer
 - Contract Number
 - Height of Poles (eg. 6m, 8m, 10m and 12m)
- The rivets used to fix the nameplate shall be non-rust type.
- An incoming cable termination-looping cutout shall be installed inside the poles by means of three 4mm diameter screws. The dimension of the looping cutout is 100mm(w) x 300mm (L) x 75 mm (D) mounted vertically.
- The supplier shall design a fixing device, which could be a perforated plate made of hot-dipped galvanised steel. The dimension of the baseboard shall be 100mm(w) x 348mm (L) mounted vertically. This is to be fixed in the pole directly facing the pole door as part of the poles. The cutout therefore can be mounted directly onto the pole. The fixing device shall be flexible to cater for different types of cutouts. The supplier shall submit their design of the fixing device together with their offer.
- Alternatively, a baseboard made of hot-dipped galvanised steel shall be provided and mounted in each poles for fixing of cut-out.

c) Technical Standards for LED street lighting

- General
 - i) The LED luminaire, including the LED's, its associated electronic control gears (Driver) and all accessories, shall be designed to fully withstand the current voltage surges of lightning strikes and the frequent switching operation of the power supplies.

- ii) Each luminaire shall consist of 2 main components consisting of an independent LED Module and Electronic Control Gear (driver).
 - iii) The driver and LED module shall be integrated into the luminaire. The driver shall be designed to be replaceable with standard compatible driver.
 - iv) The luminaire shall be of robust constructions which combine excellent functional and visual design. The luminaire shall be of dustproof and jetproof to IP65, vandalproof and shall be completed powder coated finishing.
 - v) Test reports shall be submitted from local or international Accredited Test Labs for approval.
- Luminaires
- i) Operation of LED Life Span – The rated LED life should be more than 50,000 hours at ambient temperature of 35 °C or higher.
 - ii) The luminaire shall comply with the requirements of safety extra-low voltage (SELV) system.
 - iii) Contractor shall ensure that the Luminaire design is tested to relevant local or international standards and including the followings:

IEC 60825-1	Safety of laser products – Part 1: Equipment classification and requirements
IEC 62471	Photobiological safety of lamps and lamp systems – Part 2: Guidance on manufacturing requirements relating to non-laser optical radiation safety
IEC 62031	LED module for general lighting – Safety Specification
IEC 60598-1	Luminaire – General requirements and test
LM 79	Approved method: electrical and photometric measurements of solid-state lighting products
LM 80	Approved Method: measuring lumen maintenance of LED light sources.

- LED Module
- i) The vendor shall use illumination grade LED or any other equivalent.
 - ii) The LED module shall consist of a low profile high flux LEDs with minimum IP rating of 66.
 - iii) LED module shall have nominal white light output at corresponds to the correlated color temperature in the range of between 5000K and 6000K unless otherwise indicated. The color rendering index, the target CCT

and tolerance shall be based on latest ANSI_NEMA_ANSLG C78.377, as listed below:

Nominal CCT (K)	Target CCT and Tolerance	Color Rendering Index
5000	5000 +/- 300	> 70

The LED module shall have the following information distinctly and durably marked:

- i) Trademark or mark of origin (Brand & model of LED used)
- ii) Nominal Wattage
- iii) Correlated Colour Temperature (CCT)
- iv) Colour Rendering Index
- v) Weight
- vi) Marking requirements in accordance to relevant local or international standards.

The LED Module shall have the following features:

- i) Heat sink with high thermal dissipation properties
- ii) Provisions to prevent unauthorised removal.
- iii) Corrosion resistant.
- iv) Diffuser shall be UV coated
- v) Operate in relative humidity of greater than 90%

Test result shall be provided to indicate adequate thermal performance for the long term operation of the LED's at an operating temperature of not less than 35 °C in accordance to relevant local or international standards. The LED junction temperature shall be maintained at or below manufacturer's recommendation.

The rated LED life L70/B50 shall be more than 50,000 hours at LED operating at 35 °C.

- Driver

- i) The electronic control gears shall power the LED such that the LED is flicker-free and it shall be suitable for Class 1 luminaires.
- ii) Driver shall comply with the followings:

IEC 62384	DC or AC Performance requirements.
IEC61347 Part 1 and Part 2-13	Particular requirements
IEC 61547	EMC Immunity requirement
IEC 61000-3-2	Limits for Harmonic Current Emissions

CISPR 15	Limits and methods of measurement of radio disturbance characteristic of electrical lighting and similar equipment
----------	--

iii) Driver shall satisfy following requirements:

Life Span	50,000 hours of operations at max. case temperature of 70 °C or higher
Power Factor	0.9 or better
Rated input voltage	AC 230 +/- 10 V, 50Hz
Operation Rated Output Voltage	According to SELV in luminaries
Operating Temperature	20 °C to 45 °C
Storage Temperature	20 °C to 85 °C
THD	< 15%
Efficiency	> 80%

iv) Location of driver shall be as such it shall be easily maintainable without special tools.

d) **Installation**

- All wiring to light fitting shall be enclosed with flexible conduits or G.I conduits. All terminations to light fittings by flexible conduits or G.I conduits shall be made with proper termination kits for a watertight finish.
- All surface and wall mounted fittings shall be secured with metal threaded studs complete with two lock nuts and washers using approved metal studs cartridge hammer. The threaded metal studs shall penetrate into the hard concrete to a depth of not less than 32mm.
- All pendant fittings, shall be securely fixed to the ceiling using downloads with conduit terminating boxes.
- All recessed fittings shall be supported independently. False ceiling grid system shall not be used to support light fittings. All fittings shall be adjusted so that there shall be no noticeable ceiling deflection when the fittings are installed. The fittings shall be directly secured to the soffit of the ceiling slab by means of G.I. wires tied to metal studs.

11.3.4 Intelligent Lighting Detection System

11.3.4.1 General

- i) The sensor of the ILDS shall be suitable for outdoor type and weatherproof to IP65.

- ii) The Detection System shall be capable of detecting human by using a combination of passive infrared and ultrasonic sensor other technologies will be subjected to approval.
- iii) The Detection System shall be capable of differentiating between animals and human through the means of detecting human physical measurement so as to prevent false activation.
- iv) There shall be visible indicating light at the sensor to indicate the health status of the sensor.
- v) In the event of power failure to sensors all lighting shall be automatically switch "ON".

11.3.4.2 Controller Box

- i) The controller box shall be outdoor type, weatherproof to IP 65 and of robust construction.
- ii) Internal wiring conductors shall be stranded copper wire, not less than 450/750 V class PVC insulation.
- iii) The housing shall be made of sheet steel with thickness of not less than 2.5 mm. The controller box shall be sprayed with 1 coat of anti-rust primer and 2 finishing coats of paint colour to the Authority's approval.
- iv) The metal enclosure shall be completed with hinged doors and to be provided with standardised "A" series key lock and 3 sets of key.

11.4 Lightning Protection System

11.4.1 General

- a) This section of the specification provides for the supply and installation of a complete lightning protection system. The installation shall comply with the requirements of SS 555 and any additional requirements of this specification.
- b) The lightning protection system shall comprise the following:
 - Roof conductors
 - Down Conductors
 - Jointing and bonding
 - Earth Terminations

11.4.2 Air Terminations

- a) The air terminations shall comprise of continuous lengths of horizontal conductors 25 mm x 3 mm copper and securely fixed in place to the building structure. Fixings shall be such that under abnormal cyclic conditions, the tapes shall remain firmly fixed in position.
- b) Where saddled to masonry, the fixing screws shall be set in expansion type plugs contained in properly formed holes.

- c) All roof conductors shall be secured at intervals not exceeding 900 mm. It is required to ensure that the mounting of the lightning protection tape on the roof structure shall not in any way compromise the warranty of the roof.
- d) The whole air termination system installed over its total route of roof areas shall be electrically continuous.
- e) Provision shall be made with suitable fitting to allow for expansion and contraction of the horizontal conductors.
- f) No galvanic corrosion shall take place between the lightning protection tape and the roof structure. Where possible, a narrow gap shall be maintained between the lightning protection tape and the roof structure. Insulating material shall be inserted at appropriate locations to maintain the narrow gap.

11.4.3 Down Conductors

- a) Down conductors for interconnection between roof conductors and the earth electrode shall be of 25 mm x 3 mm Copper tape. Exposed down conductors shall be securely fixed to the building structure and the support shall not exceed 600 mm intervals.
- b) The conductor routes shall be interfaced with the architectural design and shall be as direct as possible.

11.4.4 Joints and Bonds

- a) All joints shall be tinned, soldered and double riveted. The cross-sectional area of the copper materials used shall not be less than the main conductor (i.e. 25 mm x 3 mm).
- b) Clamp, bolt and screw joints, shall not be used in the circuit except at test or bonding points.
- c) Joining of dissimilar metals shall be with purpose made bimetallic joints.
- d) All structural and steel columns shall be bonded to the rebar of the floor slab to ensure a low resistance path. All bonds shall be by means of purpose made clamps or by welding where possible.

11.4.5 Earth Termination

- a) The earth electrode shall be housed with hot-dipped galvanised lid earth pit haunched in concrete and heavy-duty covers of dimension 300 mm x 300 mm.
- b) The copper tape connecting the earth electrode and down leads shall be run in 50mm diameter uPVC pipe.
- c) Earthing rods shall consist of a minimum of 2 nos 1.8 m length, 16 mm diameter copper bond steel rod.

11.5 Cable Support Systems

11.5.1 General

- a) All cable trays, ladders, trunking and conduits shall have at least forty percent (40%) spare capacity for future expansion.

- b) All metallic cable trays, ladders, trunking and conduits shall be earthed in accordance to SS CP5.
- c) All holes cut in cable trays or trunkings for the passage of cable shall be provided with grommets.
- d) Conduit entry to cable trays shall be by means of a coupling and a hexagonal male brass bush.
- e) Conduits shall be run truly vertical, horizontal or parallel with the features of the building. Conduit shall run continuous between outlets with minimum number of bends. Where uPVC conduits are bent, they must be cold bent without altering their sections with an approved type of bending spring. The conduit shall be run so as to be self draining incorporating as necessary approved means of drainage.
- f) All cable support systems shall be adequately supported to manufacturers' specifications.
- g) Contractor shall propose the colour of cable support system and subject to Authority's acceptance prior to procurement and installation work.

11.5.2 Metal Trunking and Accessories

- a) All steel trunking shall comply with SS 249 and to the approval of the Superintending Officer.
- b) The word 'ELECT' shall be marked on the underside of the cable trunking. The words shall be in black and the spacing of the marking shall not exceed an interval of 3000 mm.
- c) The trunking shall be fitted with removable covers of the same material, extending over the entire length of the trunking. The minimum thickness of the steel sheet shall be 1.2 mm.
- d) Trunking shall be supplied complete with purpose made connectors, dividers, flanges and retaining clips including cable pin tacks to avoid strain on cables on extended vertical runs. Earth continuity tags will be supplied in accordance with manufacturer's recommendations.
- e) Accessories used shall be of manufacturers' standard items. Standard tees, 90 degree bends, offset pieces, jointing sleeves etc. shall be used for the relevant applications.

11.5.3 Galvanised Iron Conduits and Accessories

- a) All conduits shall be heavy gauge, hot dipped galvanised welded steel, manufactured in accordance to BS EN 50086-1, Class 4.
- b) No conduit shall be less than 25 mm in diameter.
- c) Conduits shall be free from internal burrs, fins and the like which may cause damage to cables.
- 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 BS EN 50086-1.
- e) Circular junction boxes pull boxes and inspection boxes shall be provided with heavy gauge lids.

- 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 BS 1363 and BS 4662.

11.5.4 Flexible Conduits

- a) All flexible conduits shall be manufactured to conform to BS EN 61386-23 and shall be galvanised with PVC coating.
- b) All flexible conduits shall be provided with Brass Nickel Plated 2 Piece Adapters at both ends of the flexible conduits. An external earth wire shall be installed to link the brass connectors.

11.5.5 UPVC Conduit/Pipe and Accessories

- a) UPVC Conduit/Pipe shall be high impact-heavy gauge type, which are unscrewed without coupling and with plain ends and compliant to BS 4607: Part 5 and BS EN 50086-1. All bends shall be with standard fittings/accessories. The conduit/pipe have a module of elasticity of 30,000.
- b) All conduit used shall not be less than 25 mm in diameter.
- c) Plain conduits shall be jointed by slip type of couplers with manufacturer's standard sealing cement.
- d) All conduits entry to outlet boxes, trunkings and distribution boxes shall be made with adapters female thread and male brushes screwed.
- e) Accessories used shall be compliant to BS 4607.
- f) Standard PVC circular junction boxes shall be used with conduits for intersection, tee-junction, angle junction and terminal. For the drawing in of cables, standard circular through boxes shall be used.

11.5.6 Cable Tray and Accessories

- a) Earthing System Cable Trays used shall be of the perforated type and constructed of 1.6mm thick galvanised mild steel.
- b) Accessories used shall be of manufacturers' standard items and shall be of the same material, thickness and finish as the cable tray.

11.6 Earthing System and Equipotential Bonding

11.6.1 General

- a) All electrical equipment shall be bonded to earth by means of the conduit and trunking system or PVC insulated stranded copper conductor. The sizes and type of the cables and the method of installation shall be in accordance with SS 551.
- b) The earthing of the whole installation shall comply with the appropriate requirement of CP 5 and SS 551.
- c) All earthing tape or bonding conductors shall be green/yellow PVC insulated high conductivity copper.

- d) All metal conduit, trunking, supports, cabinets, metal parts of switchgear, equipment cases, electrical fittings and fixed appliances liable to become live in the event of insulation failure, shall be effectively earthed by means of earth continuity conductors of adequate size.
- e) The earthing continuity conductor shall be of high conductivity copper, and continuous throughout its length without joints except by exothermic connections.
- f) Earth continuity conductors from all exposed metal parts of equipment required to be earthed including earth connections to plug sockets shall be connected by one of the following appropriate methods:
 - To earth connection at the distribution board supplying the equipment on plug socket.
 - To any point on the sub-main or main earth continuity conductors supplying the relevant equipment.
- g) A separate PVC insulated earth wire shall be used in PVC conduit installations.
- h) Steel trunking shall be bonded across each joint or separate earth continuity wire shall be used.
- i) Bonding connections shall have a warning label fitted, marked “Electrical Earth - Do Not Remove”.
- j) All extraneous conductive parts e.g. metal structure, lamp post and bus service numbers post shall be bonded to the DB earth bar and. The electrical bond shall be by means of purpose made clamps or welded where possible.

11.6.2 Earth Termination

- a) The earth electrode shall be housed with hot-dipped galvanised lid earth pit haunched in concrete and heavy-duty covers of dimension 300 mm x 300 mm.
- b) Earthing rods shall consist of a minimum of 2 nos 1.8 m length, 16 mm diameter copper bond steel.

11.7 Emergency Diesel Generator System

11.7.1 General

- a) The emergency diesel generator system shall comply with the requirements stipulated in SS 535 ‘Code of Practice for Installation, operation, maintenance, performance and construction requirements of mains failure standby generating systems’.
- b) The emergency generator system shall include the following:
 - i) Diesel Engine / generator set including radiator, anti-vibration, holding-down bolts etc.
 - ii) Exhaust system including silencers, suspension and thermal insulation
 - iii) DC electric starting system
 - iv) Control panel
 - v) Fuel system including day tanks, diesel storage tanks, fuel pumps, pipes and valves.

- c) The electric system characteristics of the emergency system shall be as follows:
 - i) Nominal System Voltage: 400V, 3-phase, 50 Hertz.
 - ii) Frequency: 50 Hz
 - iii) System Neutral: Solidly earthed
- d) The emergency generator system shall have provisions for both manual and fully automatic starting facilities and be capable of transferring the designed connected load in the event of a mains failure or a deviation outside the acceptable limits and to do so in not more than 10 seconds.
- e) The emergency generator system shall be adequately sized to meet the load requirements to serve essential loads which consists of sump pumps, lifts, ejector pumps, fire related mechanical ventilation system, fire protection system and all essential equipment as required by local codes and standards. Details of the selection shall be submitted the LTA for acceptance. The selection of the emergency generator system shall take into consideration the following:
 - i) Derating factors
 - ii) Transient voltage dip
 - iii) Instability due to interaction between voltage regulation systems
 - iv) A 10% overload capacity in excess of the nameplate continuous rating for one hour in any of twelve (12) consecutive hours of full load operation.
- f) When the diesel engine generator sets are in operation, the room temperature shall not exceed 40°C.

11.7.2 Diesel Engine

- a) The performance of the engine shall conform to the requirements stipulated in ISO 3046 and ISO 8525.
- b) The engine shall be rated for continuous duty and sized to match the continuous rating of the generator with overload capacity as specified.
- c) The engine shall be direct injection, cold starting, water-cooled, pressure lubricated, four-stroke, single-acting compressor ignition diesel engine type.
- d) The engine shall be suitable for running on diesel conforming to BS EN 590 and BS 2869: Part 2 (Class A2).
- e) Engine lubrication shall be by pressure lubrication throughout the whole engine with an engine driven oil pump - a unit mounted oil-to-coolant heat exchanger and unit mounted multiple oil filters with removable elements so located as to provide easy access and maintenance.
- f) The governor shall be of the electronic type, with adjustable speed regulation and motorised control integral with the fuel injection pump, and suitable for maintaining constant engine speed within the limits specified in BS 5514, Class A.
- g) The engine shall be provided with the following minimum indications:
 - i) Oil pressure
 - ii) Oil temperature
 - iii) Engine temperature
 - iv) Tachometer
 - v) Exhaust Gas thermometer

- vi) Cooling Water Temperature
- vii) Cooling water thermometer on inlet to lubrication oil cooler
- viii) Run time counter
- ix) Battery charger ammeter/ voltmeter
- x) Generator output wattmeter, voltmeter and ammeter
- h) The engine shall be provided with the following protective devices and control as a minimum to effect early warning and shutdown in the event of the following:
 - i) Low lubricating oil pressure
 - ii) High engine coolant temperature
 - iii) Low coolant level
 - iv) Engine over-speed
 - v) Engine over-crank
 - vi) Low Fuel level

11.7.3 Alternator

- a) The alternator shall comply with the requirements stipulated in BS 5000.
- b) The alternator shall be screen protected and drip proof in accordance with BS 5000.
- c) The alternator shall be brushless, self-exciting and self-regulating type
- d) The alternator shall be capable of withstanding an overspeed of 20% above synchronous values for 2 minutes without mechanical damage or permanent distortion. Mechanical protection of the alternator shall be provided by the engine overspeed protection devices specified.
- e) The alternator shall be capable of withstanding an unbalanced load with the current in one-phase more than the other phases by 60%.
- f) The alternator shall withstand 3-phase short-circuit conditions without damage. Excitation shall be maintained under external fault conditions to produce a short-circuit current of 3 times full load.
- g) Steady-state voltage variation shall not exceed +1% from no-load to full-load. The alternator shall be capable of supplying its rated KVA output at rated speed and power factor at voltages ranges from +2% to -2% at rated value.
- h) The alternator shall be capable of supplying its rated KVA output at rated voltage and power factor at frequency ranging from +2% to -2% at rated value.
- i) The alternator shall be capable of withstanding for 15 seconds a current 50% in excess of its rated current with the field set for rated load excitation.
- j) For suddenly applied load conditions, recovery of stable condition shall start within 500ms and frequency regulation shall not exceed 2 Hz from no-load to rated load.
- k) Alternator and exciter windings shall be rated for a maximum hot spot temperature of 130°C and the alternator field windings shall be rated for a maximum hot spot temperature of 155°C in accordance with BS 2557. The windings shall be treated for the Singapore tropical climate. The stator and rotor windings shall also have an oil resistant finish.
- l) The alternator shall be 400V, three-phase, 50 Hz, Y connected with the neutral solidly earthed. The neutral terminal bar of tinned copper shall be brought out for connected to the earth.

- m) The alternator voltage shall have minimum total harmonic distortion in compliance with BS 5000. Radio interference suppression shall be in accordance with the applicable British Standards.
- n) The alternator shall be built-in with thermostatically controlled heater and with manual isolating switch at the control panel.
- o) Single bearing alternator will not be acceptable.

11.7.4 DC Electric Starting System

- a) The emergency generator set shall be electrically started with an engine motor starter suitable for 24 VDC operation. The battery shall be nickel-cadmium type and shall be mounted adjacent to the engine under-base.
- b) The starting equipment shall incorporate a fail-to-start device for automatically disconnecting the starter motor if the engine fails to start within a pre-determined time, so as to avoid undue discharge of the batteries. The fail-to-start device shall operate a visual and audible alarm. No further attempts shall be made to start the engine by the automatic starting system until the fail-to-start mechanism has been reset manually.
- c) The battery shall be sized for six consecutive attempts of thirty seconds cranking time without recharging. The batteries shall be housed in a corrosion resistant and flame retardant container of an approved type. The detailed calculations for the battery capacity shall be submitted to the LTA for acceptance.
- d) A current limiting constant voltage charger, with boost charging facilities shall be provided. The voltage regulation shall be within +/- 1% of the voltage output. The engine starting control equipment shall be arranged to disconnect the charger to prevent it being overloaded during starting. The charger shall have the capacity to fully recharge the battery in 24 hours.

11.7.5 Control Panel

- a) The control panel shall be manufactured from sheet steel of minimum thickness 2mm. It shall have provisions for hoisting and be dust and vermin proof.
- b) The control panel shall be arranged for front access wiring. The control panel shall be provided with removable plates on the top and bottom, complete with knock-out holes, cable glands and supports to enable installation and termination of incoming and outgoing cables.
- c) The function of Generator Control Panel's Local / Auto / Test selector switch is as indicated below:
 - (i) "Auto" refers to automatic start up of the generator upon power failure of the normal incomer of the MSBs.
 - (ii) "Local" refer to manual start up of the generator
 - (iii) "Test" refer to automatic start up of generator for test run
- d) The control panel shall contain but not be limited to the following:
 - 1. Four pole Air Circuit Breaker with adjustable trips for generator overcurrent, earth fault and reverse power relays, controls and indications as specified. The

current rating and breaking capacity of the ACB shall be compatible with the generator provided.

2. The following instruments, alarms and indicators and control equipment.

Instruments	Audible Alarm and Indicator	Control Accessories
Frequency Meter	High water temperature alarm	Starter control for radiator motor
Voltmeter with selector indication of phase to phase and phase to neutral voltage	“Engine” Fault auto shut down and reset	Instrument Transformers and rectifiers and control fuses
Ammeter with current transformer and selector switch	Low lubricating oil pressure	Incoming ACB or MCCB with over current and earth leakage protection
Manual voltage adjusting rheostat	High lubricating oil temperature	Engine auto/manual start control and protection relays
Running hour meter	Unit over speed	
Local/Auto/Test Selector, manual start/stop push button	Generator overload/single phasing	
Lamp test button	Battery healthy	
Kilowatt meter	Failure to start	
Power Factor Meter		

- e) All wiring shall be FRT insulated type with a minimum size of 1.5mm²
- f) Wiring shall be carried out on the front surface of the mounting plate neatly strapped in cable trunking of the ventilated type with clip-on covers and purpose made connector pieces and accessories
- g) All wiring shall be identified with numbered ferrules.
- h) Terminals shall be suitably rated, fully fitted and numbered. They shall be normally mounted for top entry and front access. They shall be suitably sized to cater for long runs of externally mounted cables where voltage drops necessitate a larger size than standard for the connected load.
- i) All tools including charging handle, necessary for manual operation and maintenance of ACB shall be provided for the Generator Control Panel.
- j) The operation of the generator shall comply as follows:
The control panel shall be designed for automatic operation on mains power supply failure.
 - i) When the mains power supply is available, the load is fed through the mains supply switch of the automatic transfer switches.
 - ii) The automatic control circuitry shall be arranged such that a fault or failure of the mains power supply and on receipt of such a signal, the mains power supply shall be isolated and the engine starting initiated.

- iii) The main power supply voltage sensing unit shall not only detect a complete main power supply failure but shall also sense a voltage drop of up to 20% or more in any phase of the normal mains voltage.
 - iv) When the voltage and frequency of the generator reaches the normal values, the automatic transfer switch is transferred and the loads are fed from the emergency generator system.
 - v) The duration of the entire starting sequence shall be within ten seconds from the moment of mains power failure to standby power supply.
 - vi) When the mains power supply returns to normal, the loads shall be transferred automatically to the main power supply. Time delay circuits shall be incorporated in the control circuit of the generators such that the changeover to mains power supply has been resumed shall only be effected after the engine has run for a minimum period of 15 minutes after start-up and 15 minutes after mains resumption to ensure that the engine is not repeatedly started and stopped in the event of a series of supply interruptions. The generator shall shut down after a preset time delay and the equipment shall reset for the next duty operation.
 - vii) A sequential start shall be incorporated. The loads to be designated for each step shall be subject to approval by the LTA.
- k) The emergency generator system shall be provided with overcurrent and earth fault protection relays as indicated below:

	Type of Protection	Setting Range
Overcurrent	IDMTL	50% to 200%
Earth Fault	IDMTL	10% to 40%
Restricted Earth Fault	High Impedance	15-100 volts

The developer shall select the appropriate current transformers to achieve the above protection schemes.

11.7.6 Fuel System

- a) The fuel system shall include bulk storage tanks, day tanks, fuel pumps and associated pipe works and accessories. The fuel system shall be sized to provide a minimum of 6 hours of full-load emergency back-up.
- b) Fuel tanks shall comply with the requirements of the relevant authorities and SS532.
- c) The developer shall provide mild steel day service tanks to maximum capacity permitted by relevant authorities' requirements. Fuel level indicator shall be provided. The day service tank shall be suitably corrosion protected and fabricated from 3 mm thick mild steel plate primer coated twice on inside and outside and finish coat with glossy enamel paint. Suitable measures of containing 100% oil spill from the tank shall be provided.
- d) The day service tanks shall be supported on a rigid steel angle stand at a level suitable for priming of the fuel suction line for the generator while not imposing danger of causing fuel leakage through the isolation valve while the unit is

- stationary. All interconnecting fuel pipework between fuel day tank and engine shall be Grade 316 stainless steel pipes.
- e) The bulk and day tank vent pipes shall be located in a suitable location to allow the personnel filling the respective tank, via the fuel inlet chamber, to view the vent pipe outlets.
 - f) Two fuel transfer pumps shall be installed to pump fuel from the bulk fuel tank to the day tank. The pump control shall be wired for alternate operation sequence, one on standby with automatic changeover from pump 1 to pump 2 and vice versa. Fuel leakage alarm shall be provided at the pump control panel. Separate Fuel leakage detectors within the day tank and bulk tank bund walls shall be provided.

11.7.7 Generator Room Requirements

- a) Maintenance clearance of 900mm shall be provided around the emergency generator system to permit inspection, maintenance and repair of the system.
- b) Proper acoustic treatment shall be incorporated to reduce the noise level during generator operation such that the noise level measured at 1 metre from the circumference outside the generator room shall not exceed 85 dBA.
- c) The developer shall provide the following:
 - i) Rubber mats of at least 5mm thick and 600mm wide shall be provided for the entire length in front of floor mounted switchboards and the control panel.
 - ii) Framed single-line drawings, endorsed by LEW, showing clearly the full details of the electrical services supplied and installed.
 - iii) Statutory safety notices, regulations and instruction for resuscitation and treatment after electrical shock.
 - iv) Danger signs in 4 languages displayed on switchboards / control panels / doors for electrical rooms complying with the requirements of the Energy Market Authority.
 - v) Suitable metal cabinet (A2 size) for writing purposes, installed next to the framed single-line drawing.
 - vi) Key cabinets with sufficient capacity for the number of keys required for padlocking all circuit breakers and all the keys for control switches on the entire LV main switchboards.
 - vii) A4 size log-book for recording of all access to and activities in the generator room.
 - viii) Two numbers of one litre capacity eye washes shall be wall-mounted adjacent to the battery bank.
 - ix) Fire extinguishers
 - x) Ear protection gear according to relevant regulations and standards.
 - xi) Beacon light outside the generator room to indicate that the emergency generator system is in operation.

11.8 Water Services, Sanitary Works and Pumped Drainage System

11.8.1 Pipe work

- a) Unless otherwise specified, only one type of pipe shall be used within any individual pipe length.
- b) Valves shall be installed in horizontal lines with stems either horizontal or vertical. Isolation valves shall be installed at any other points indicated or required for draining, isolation, or sectionalising purposes. Valves shall be installed in such a manner that maintenance access is maintained for all parts requiring service. Control valves shall be provided in water pipes to provide complete regulation of plumbing fixtures and equipment.
- c) All fixtures, hangers, supports and brackets for pipes, trunking, conduits, trays, equipment etc. shall be of hot dipped galvanised to BS EN ISO 1461.
- d) Bolts and nuts shall be accompanied with washers. All these shall be hot dipped galvanised to BS 7371 : Part 6 or sherardised to BS7371 : Part 8, Class S1.

11.8.2 Sewage Ejector Pumping System

- a) Sewage ejector pumps shall be of the duplex non-clogging type suitable for handling raw sewage. A minimum of two pumps (duty/standby) and an ejector tank shall be provided for each sewage ejector pumping system. Each pump shall be designed for 2 times the peak sewage/wastewater inflow generated. A sewage sump pump shall be provided in the sump pit and connected to the sewage ejector pumping main for containment of over spillage of sewage from ejector tank.
- b) All ejector pumps with motor sizes larger than 7.5 KW shall be provided with a moisture detector with alarm signal/light connected to the pump control panel.
- c) Operation shall be automatic and controlled by float switches. If the level continues to rise after starting the duty pump the standby pump shall be started. Provide lead/lag selector switch, hour run meters for each pump and high level alarm. Gates valves shall be provided on the suction, discharge sides of the pump and before inlet to ejector tank. Discharge pipe work of minimum 100mm diameter shall consist of check valve of single flap type-
- d) The pump shall be designed to cater for minimum 10 starts/stops per hour. However, the motor starter shall be sized to 15 starts/stops per hour.
- e) All fixtures, hangers, supports, brackets, guide rails, chains, bolts, nuts and all related accessories in the pumped drainage system shall be of stainless steel.
- f) The layout shall be such as to facilitate easy removal and replacement of pumps. Lifting facilities (e.g., overhead runway beam, eye bolt etc.) and equipment shall be provided to enable easy lifting of the tanks/pumps. Adequate removable chain blocks shall be provided.

11.8.3 Pumped Drainage System

- a) The drainage pumped system shall consist of duty and standby pumps, water level sensors, electrical and control wiring/system, all associated pipe work, fittings and accessories. The system shall also include one smaller submersible drainage pump, which serve to dewater the sump pit for maintenance purposes, where applicable.

- b) Drainage pumps shall be of vertical centrifugal submersible type, capable of handling and pumping wastewater with solid particles of at least 80mm without clogging. Installation of the pumps to the discharge connection shall be the result of a simple linear downward motion of the pumps guided by two guide-rails. The entire weight of the pump/motor unit shall be borne by the pump discharge elbow. No portion of the pump/motor unit shall bear on the sump floor directly or on a sump floor mounted stand. The pumps shall be easily removable for inspection or service, requiring no bolts, nuts or other fastenings to be disconnected.
- c) The pump shall be designed to cater for minimum 10 start/stop per hour. However, the motor starter shall be sized to 15 starts/stops per hour. The design Pump Capacity, Q_p shall be a minimum of $Q_p = 2Q_{in}$ (total inflow) and ensure that the velocity of water in the discharge pipes is between 1.0m/s and 2.4m/s. Discharge pipe shall have a minimum diameter of 80mm.
- d) Check valve of single flap type and a gate valve shall be provided on the discharge main of every pump. They shall be located above the sump such that they are accessible without the need to enter the sump and after removal of the access cover.
- e) All fixtures, hangers, supports, brackets, guide rails, chains, bolts, nuts and all related accessories in the pumped drainage system shall be of stainless steel.
- f) The layout shall be such as to facilitate easy removal and replacement of pumps without entering the sump. Lifting facilities (e.g., overhead runway beam, eye bolt etc.) and equipment shall be provided to enable easy lifting of the pumps. Adequate removable chain blocks shall be provided.
- g) For each sump pump, a control panel shall be placed at a convenient, easily accessible location and shall be constructed with a waterproof type enclosure.
- h) Control of the pump shall be carried out by the following methods:
 - Automatic operation by means of float level switches.
 - Manual operation by means of 'start' and 'stop' manual actuation on the local pump control panel.
 - Automatic changeover of duty and standby pumps during each cycle of operation. This is to enable even distribution of wear and tear of the pumps.

11.8.4 Motor Control Panel

- a) The motor control panel (MCP) shall be of front access cubicle type of dust and vermin proof construction and is adequately ventilated. It shall be fabricated from 2mm thick sheet steel, pressed or rolled to the shape required with all necessary stiffeners, supports and return edges. All joints shall be neatly welded and finished flush. Nuts, bolts, washers, etc. shall be cadmium plated or sherardised.
- b) The panels shall be finished with high quality enamel. A minimum of two undercoats applied, each built-up and flattened separately. The final coat shall be of an accepted gloss finish and sufficient body given to the paint films so that the final appearance of the finished units is entirely free from blemishes, undulations, foreign inclusions, scratches, patterning or any defects whatsoever.

- c) The door of each control panel shall be furnished with a key-lock under a master key for all motor control panels installed. Cylinder locks shall be used. Three sets of keys shall be provided.
- d) Interface compartment incorporating properly labelled terminal block shall be provided for connections to the Interface Terminal Board (ITB). The control cables shall be properly terminated in the ITB.
- e) The MCP enclosure shall be designed to IP 55.
- f) The isolator shall isolate the linkage between the pump and motor control panel. The isolator shall be of IP 55.

11.8.5 Motor Starter and Motor

- a) Starters for motors up to 5 kW shall have thermally operated overload units incorporating single phasing protection and ambient temperature compensation with under voltage release facilities. Motors over 5kW shall have thermistors fitted to operate the under voltage release and the necessary control units shall be supplied for these starters.
- b) Each starter shall be complete with overload protection incorporating the following features:
 - Overload protection in each phase supply.
 - Adjustable over the range of 80 percent to 120 percent full load.
 - Manual reset.
- c) Motor starters shall generally be of the following types:
 - Up to 2.2 KW motors - Direct-on-line (DOL) starters
 - Above 2.2 KW up to 11 KW motors - Star-Delta starters
 - KW motors and above - Solid state (Soft) or other reduced voltage starters with a maximum starting current of 2 times the full load current.
- d) All motors, unless otherwise specified on the Drawings or in this Specification, shall be totally enclosed fan cooled (TEFC), squirrel cage induction type conforming to either IEC 34-1 and IEC 85 or BS 5000 and BS 2757 with minimum class F insulation. All varnishes and impregnate used shall be inorganic and suitable for tropical service. Bearings shall be so selected for its duty and shall be housed in a dust tight enclosure with efficient shaft seals to prevent dust ingress and escape of grease, and be equipped with grease nipples and relief plugs. Terminal boxes shall be of cast iron and be provided with glands drilled and taped to accept conduits. Terminal blocks shall be of high quality insulating materials and be capable to support incoming cables.
- e) All motors shall be so selected to have at least 120% of the power rating above the designed duty point. It shall also be able to operate with a power factor of not less than 0.85 at full load, otherwise, power factor correction capacitors shall be provided.
- f) Motors shall be capable of operating continuously at rated output at any frequency between 50 and 52 Hz and at voltage within 10 percent of the nominal value.
- g) Motors shall be tropicalised to BS 1156 with minimum 1 mega-ohm insulation resistance.

- h) All motors shall be supplied complete with cable termination boxes and mounting bolts.
- i) Single-phase motors shall be either repulsion or capacitor start and induction run. Motors rated 1 KW and above shall be operated by three-phase supply.
- j) All motors shall be protected and a detection and tripping device shall be provided for as follows:

Phase protection	Upon failure of one phase, motor shall be protected from operation on two phases.
Overcurrent protection	Upon the detection of overcurrent to the motor, its shall shutdown automatically.

11.8.6 Special Requirement for Motor of Sump Pumps

- a) The motor shall be housed in an air filled watertight chamber enclosure rated IP 68. The stator shall be dipped and baked three times in Class F varnish and shall be heat sink fitted into the stator housing. The use of bolts, pins or other fastening devices requiring penetration of the stator housing is not acceptable. The motor shall be specifically designed for submersible pump usage and designed for continuous duty pumping media of up to 400°C (1040 °F). The motor should be designed for 15 starts/stops per hour.
- b) The pump capacity of 7.5 KW and above shall have thermal switches embedded in the stator lead coils to monitor the temperature of each phase winding. These thermal switches shall be set to open at 1250 °C and shall be used in conjunction with and supplemental to external motor overload protection. Should high temperature occur, the thermal switches should open, stop the motor and activate alarm.
- c) The motor shall have a voltage tolerance of plus or minus 10%. The motor shall be designed for operation up to 400 °C (1040 °F) ambient and with an average temperature rise of the stator windings not to exceed 800 °C. A performance chart shall be provided showing curves for torque, current, power factor, input/output KW and efficiency. This chart shall also include data on starting and no-load characteristics.
- d) Water leakage/ moisture sensors shall be provided to detect liquid/ moisture in the motor housing. Use of voltage sensitive solid state sensors shall not be allowed.
- e) The junction chamber shall contain two distinct and separate terminal boards. One terminal board shall be used for the connection of the pilot sensor leads with the pilot sensor cable. A separate terminal board shall be utilized for the line power connection to the motor stator leads. This power terminal board shall use threaded compression type binding posts to connect the cable conductors and motor stator leads.
- f) The power terminal board shall separate and seal the junction chamber from the stator housing. The use of wire nuts or crimping type connectors is not acceptable. The cable entry junction chamber and motor shall be separated by

feed through type terminal board of non-hygroscopic material, which shall isolate the stator housing from foreign material gaining access through the pump top.

- g) The power cable shall be sized to the IEC Standards and shall be of sufficient length to reach the junction box without the need of any slices. The cables used shall be suitable for marine environment. The outer jacket of the cable shall be of oil resistant chloroprene rubber with low water absorption, and with mechanical flexibility to withstand the pressure at the cable entry. The motor and cable shall be capable of continuous submergence without loss of watertight integrity to a depth of at least 20m.
- h) The cable entry seal design shall preclude specific torque requirements to ensure a watertight and submersible seal. The cable entry shall consist of dual cylindrical elastomer sleeves, flanked by washers, all having a close tolerance fit against the cable and the cable entry. The sleeves shall be compressed by the cable entry unit, thus providing a strain relief function.
- i) The assembly shall permit easy changing of the cable. Epoxies, silicones, or other secondary sealing systems shall not be considered acceptable. Moisture sensors shall be provided to detect liquid/ moisture in the cable terminal and linked to the pump control and monitoring unit(s). Use of voltage sensitive solid state sensors shall not be allowed.

11.9 Passenger Lift

11.9.1 Design Requirements

- a) Unless otherwise stated, this technical specification defines the requirements for the design, supply, delivery, installation, testing and commissioning of machine roomless lifts.
- b) The lift shall comply strictly with all statutory regulations, by-laws and orders currently in force. Unless otherwise stated herein, the lift shall comply with the latest edition of SS 550 and Code on Accessibility in the Built Environment.
- c) Lifts provided shall have a minimum rated load (capacity) of 1020kg. However, lifts for Pedestrian Overhead Bridges shall have a minimum rated load (capacity) of 750kg. The rated speed shall be 1.0m/s in either direction for all lifts. Both car and landing entrance clear opening width and height shall not be less than 1000mm and 2100mm respectively.
- d) Each lift shall have its own traction drive machine, which makes use of sheaves and ropes. Unless otherwise specified, machine roomless lift type shall be used.
- e) The design life of the lifts shall be a minimum of 20 years with the inspections and maintenance being carried out in accordance with the supplier's Operation and Maintenance Manuals and as accepted by the Authority.
- f) All electrical equipment and control panels that are installed in the lift hoistway/lift motor room/lift landings and the car top safety switches shall be rated to a minimum of IP 21 except for the door locks which, shall be at least of IP 42 or IP2X with cover to prevent water ingress.
- g) The car operating panels (COP) and the car call buttons shall be ergonomically designed and of robust construction to the Authority's acceptance. The COP shall

be supplied and flush mounted on the front return panel of each lift car entrance or the side wall panel of the lift car.

- h) A two-panel centre-opening door system shall be provided. The door shall be of at least 1.5mm thick stainless steel, hairline (grade 304). A door vision panel, in compliance with SS 550 shall be included
- i) The lift car shall be ventilated to a minimum of 80 air changes per hour. The noise from the fan measured at a distance of 1 metre away within the lift car shall not exceed 60 dbA. The grille for the fans shall be designed to provide good ventilation within the lift car to achieve an average air velocity of at least 1.2m/s at the car centre and perimeter 1.2m high from the car floor.
- j) The finishes and ceiling details of the lift car shall be co-ordinated and subjected to the Authority's acceptance. If specified, a mock-up of the lift car, lift entrance and landing equipment shall be built to assess and verify the adequacy and quality of the finishes.
- k) The equipment shall comply with the EMC emissions and immunity tests in accordance with appropriate international standards for equipment operation in similar environment or as specified by the Authority.

11.9.2 Safety Requirements

- a) A battery operated ARD shall be provided to bring the lift car to the nearest landing in the event of power failure. During this operation all safety features of the lift shall remain operational. The rescue time of the device from the time of power failure to the time the doors fully open at the nearest landing shall not exceed 2 minutes. The landing accuracy shall be ± 10.0 mm.
- b) The ARD shall not modify the lift design and all its original safety features and shall not in any way affect the performance of the lift.
- c) The car door shall not open under any conditions (including power failure) whilst the car is in motion or stalled outside the unlocking zone of a landing. The car and landing doors shall only be opened in the unlocking zone of a landing with a landing key of an approved type.
- d) An overload device shall operate when the car load exceeds its rated load. When activated, the lift shall not move, and a warning buzzer and an illuminated "Overload" sign shall be activated. The "Overload" sign shall be incorporated in the COP.
- e) A control panel shall be fitted on the top of the lift car for maintenance purpose. The design of the control panel shall comply with the following requirements and prevent the lift car from being operated accidentally:
 - (i) It shall not be possible to control the lift car from any other location after the NORMAL/TEST changeover switch has been set to the TEST position. When in the TEST position the UP and DOWN continuous pressure push buttons within this panel shall become operative.
 - (ii) The lift car shall only move when all safety devices are in proper order.
 - (iii) The lift car shall move in either direction only on continuous pressure of the appropriate direction button at a car speed not exceeding 0.25m/s.
 - (iv) An emergency mushroom stop switch shall be provided.

- (v) The control panel shall incorporate a 13A metalclad switch socket outlet and a light fixture with switch. The light fixture shall be permanently installed and adequately protected.
- (vii) Means shall be provided to turn off the power to the door operating device and operate the doors for maintenance and testing purpose.
- (viii) Associated with this control, terminal stop limit switches shall be provided to stop the car from travelling in an upward direction not less than 1.8m from the soffit of the lift hoistway as well as before the car reaches the down final limit switch. When these switches are activated, it shall not stop the car from operating in the opposite direction
- g) The lift shall have a floor levelling device which shall automatically bring the lift car to stop within $\pm 5\text{mm}$ of the landing floor level for which a stop has been initiated regardless of the load or direction of travel.
- h) Each lift car shall be provided with progressive type safety gear mounted on the lower member of the car frame structure. This safety gear shall be capable of operating only in the downward direction and capable of stopping the car with full load at the tripping speed of the overspeed governor, by gripping the guides and holding the car stationary. The motor circuit shall be opened by a switch on the safety gear before, or at the same time the safety gear is applied. It shall be possible to release the safety gear by raising the lift car without the use of any special tools.
- i) An overspeed governor shall be provided, which is capable of activating the safety gear in the event of the lift exceeding the rated speed by 15%. The tripping of the overspeed governor for the car safety gear shall occur when the car speed exceeds 115% of the rated speed downwards. An electrically operated safety switch shall be provided to disconnect the power supply to the motor when the governor is activated. Overspeed governors, which are remote re-settable from the controller/EI panel shall be provided. Manual resetting overspeed governor shall only be considered if it is located in the lift pit or in the hoistway whereby the maintenance staff could easily and safely access to mechanically reset the governor.
- j) A phase protection device shall be provided in the controller of each lift to prevent the lift car from moving in the event of phase failure or the phase of the power supply being reversed due to any reason whatsoever. This device, when activated, shall cause a visual indicator to illuminate on the controller, until the fault has been rectified.
- k) Electrically operated proximity detector device(s) shall be installed on the leading edge of the car doors. The device(s) shall create a 3-dimensional zone of protection for the entire height of the door opening. This zone of detection shall extend a short distance in front of the landing doors. The zone of detection shall move forward as the doors close and the presence of a person, if within this zone, shall activate the detector to stop the closing movement of the doors and re-open them before hitting the person. After a pre-set time interval (which is programmable) the doors shall start to close again in the absence of further interruption. A passenger entering or leaving the car shall not cause the doors to stop and re-open unless the doors' edge reaches a certain predetermined proximity to the passenger.
- l) Car and Hall position indicator shall be provided above each car door. The faceplate of the car position indicator shall be made of stainless steel grade 304

hairline-finished. Floor numbers shall be digitally displayed using yellow or light green round or square-dot LEDs panel of not less than 30mm(H) x 600mm(L). There shall be an arrow in motion vividly and dynamically indicating car movement and direction. It shall be capable of displaying scrolling and blinking messages such as, "Out of Service," "Under Maintenance" etc. The list of messages shall subject to the acceptance by the Engineer. The surface of the display unit shall be of non-glare type.

- m) A 2-level detection device, such as float sensors/switches, shall be provided in the lift pit. The 1st sensor shall notify the Operator once the pit is accumulating water, upon reaching the 2nd sensor, the lift shall home to the designated landing and render the lift inoperative. A cut off drain shall be provided across before the entrance level landing of the lifts to prevent water ingress into the lift shaft.
- n) If the PUP or BI is linked to a Fire Command Centre (FCC), a Lift Supervisory Panel or a mimic panel indicating the position of the lifts shall be provided within the FCC. The location and contents of the panel shall be subject to the acceptance of the Authority.
- o) The finishes of the lift car and hall equipment shall be of 1.5mm-hairline stainless steel grade 304, with flooring that commensurate or is similar with the lift lobby. All finishes shall be subject to the acceptance of the Authority.

11.9.3 Cable Requirements

- a) All cables shall comply with the requirements of SS CP5 and the EMA regulations and requirements. The main power cable providing the electricity supply to a lift installation shall be at least of FR type.
- b) Flexible flat travelling cables shall be provided and conform to the latest SS 358/EN 50214. It shall be securely clamped at each end so that the weight is not supported by any fixing of the various cores. A total spare of 10 or 10% of the total number of wires used whichever is more and 2 spare shield cables shall be provided per lift.
- c) All cables shall run in galvanised steel conduit or galvanised steel trunking. The steel conduit shall comply with SS100 and BS4568 Part I & II, Class 4. The steel trunking shall comply with SS249. All galvanising of cable support shall be in accordance to BS729 and BS4921. Compression glands for cables shall comply with BS6121. Flexible conduit used shall be enhanced low fire hazard, polyolefin covered galvanised steel conduit. All conduit outlets shall be bushed appropriately. All cable support connections including to all electrical fixtures shall be watertight.

11.9.4 Provisions for People with Special Needs

All lifts provided shall comply with the Code on Accessibility in the Built Environment and the following:

- a) An international symbol of access for the disabled shall be permanently and conspicuously displayed at each and every lift landing next to the lift entrance. The size of the symbol and its position shall be subjected to the Authority's acceptance.
- b) Braille notations and raised numerals indicating the floor levels shall be incorporated on each button at COP and the hall call buttons.

- c) A recorded voice system for announcing the car position, opening/closing of doors, direction of travel and other messages shall be provided. The system shall be capable of storing not less than 25 recorded messages.
- d) All buttons shall be of micro movement/pressure type. The response light shall be orange or red when illuminated. Floor buttons shall be provided with the floor names on the right side of each button.
- e) An intermittent buzzer tone shall be used to inform the passengers throughout the opening and closing of car doors.
- f) An audio signal such as beep tone shall be sounded to signal each hall/car call registered.
- g) The volume of the buzzer/beep tone shall be adjustable from 60dbA to 70dbA as measured at the centre of the door opening.
- h) Blinking light on the emergency bell button shall be clearly visible when it is being activated.

11.9.5 Lift Inter-Communication System

- a) A lift inter-communication system of the simultaneous communication voice activated type shall be provided in each lift.
- b) Master stations shall comprise a receiver set, a transmitter set, a microphone/loudspeaker unit, buzzer, system-on and reset button(s) and system-on indication light. Slave stations shall comprise a transmitter set and a microphone/loudspeaker. All stations shall be equipped with handsets except those slave stations installed inside the lift cars, which shall be of the hands-free type.
- c) A master station shall be supplied and installed in the Passenger Service Office (PSO) (at Bus interchange only) and EI panel. The stations in the EI and PSO shall alternate their role as a master station in the normal lift operation mode and special emergency operation mode (except in the event of power failure) respectively.
- d) A slave station shall be supplied and installed in each lift car. The loudspeaker and microphone unit of the slave station in the lift car shall be concealed in the car-operating panel.
- e) Where the intercom system is not connected to a control centre, a signal shall be sent and latched-on to the Operator through the Building Management System (BMS) when the alarm or intercom button has been depressed for more than a pre-set time.
- f) A lift management, monitoring and fault diagnostic system that will serve the purpose of keeping track historical events to help in the analysis the lift performance when incidents occurred shall be provided subject to the Authority's acceptance.

11.10 Escalators

11.10.1 Design Requirement

- a) This technical specification defines the requirements for the design, supply, delivery, installation, testing and commissioning of escalators.
- b) The escalator shall comply strictly with all statutory regulations, by-laws and orders currently in force. Unless otherwise stated herein, the escalator shall comply with the latest edition of SS CP 15 and SS CP5.
- c) Escalators shall be reversible and capable of continuous operation in both directions for a period of 20 hours a day, seven (7) days a week 365 days per annum.
- d) Escalators shall be of the heavy-duty type with a design life of at least 20 years, which requires no major repairs for the first 10 years. Major repairs shall consist of repairs to the steps, track system, step chains, main drive system, traction machines, landing plates and tension carriage due to causes other than those attributable to normal wear and tear.
- e) When provided, escalators traversing in the up and/or down directions may be provided linking all levels of the Pedestrian Overhead Bridge (POB), Pedestrian Underpass (PUP) and Bus Interchange (BI).
- f) Escalators shall be designed for installation and operation at an angle of inclination of 30°.
- g) Operating speeds of the escalators shall be as follows:

	Commercial Escalator (m/s)	Transit Escalator*
Rated Speed	0.50 **	0.75 m/s
Standby Speed	Fixed at 0.13 to 0.25 m/s	Fixed at 0.13 to 0.25 m/s
Maintenance Speed	< 0.25 m/s	< 0.25 m/s

*1) Escalator that is contained in a Commuter Facility that connects with a transit station.

*2) All transit escalators shall comply with the requirements of the Public Service Escalators as stipulated in SS CP 15.

**) The rated speed of escalators at Bus Interchange shall be subjected to Authority's requirement.

- h) The truss shall be supported at both ends and at intermediate points where required with resilient supports and bearing plates. No intermediate support(s) shall be provided for escalators with vertical rise of 6.0m and below. The truss shall be designed to support the dead weight of the escalator plus the passenger load.
- i) Radii of the upper and lower transitional tracks shall be equal to or greater than the following:

	Commercial Escalator	Transit Escalator*
Upper	2.0m	3.6m
Lower	1.5m	2.0m

*1) Escalator that is contained in a Commuter Facility that connects with a transit station.

- *2) All transit escalators shall comply with the requirements of the Public Service Escalators as stipulated in SS CP 15.
- j) Replacement of the step chain wheels/ rollers shall not require dismantling any part of the chain. All chain pins shall be circlipped. Each step chain shall be provided with an automatic tension device to ensure proper tension under varying load conditions. A method shall be provided to shorten the chain by one step to compensate for chain elongation. The step chain pin pressure of all escalators shall not exceed 20N/mm².
 - k) Steps shall have a tread width of at least 1000mm and 400mm deep and not more than 210mm high. For commercial escalators, three (3) flat steps shall be provided at both upper and lower landings. Four (4) steps shall be provided on both landings for transit escalator.
 - l) The step and step chain rollers shall have durable elastomer materials bonded to a metal die case hub. The Shore hardness of the tyre materials shall be 92° ± 3°A when cured. The bond shall have sufficient strength to avoid de-trying under all load conditions. The minimum diameter of the roller and the trailer rollers shall be 75mm. The roller shall have a minimum width of 20mm.
 - m) Handrails shall have a service life of at least seven (7) years under the stipulated operating conditions.
 - n) Handrails shall have inserts and sliding surfaces of endless construction designs, synthetic materials, traction type, with a single, smooth vulcanised joint. The minimum breaking strength of the joint shall be greater than 85% of the minimum breaking strength of the handrail. The hardness of the outer stock shall not be less than Shore 70° ± 5A°.
 - o) The equipment shall comply with the EMC emissions and immunity tests in accordance with appropriate international standards for equipment operation in similar environment or as specified by the Authority.
 - p) All electrical equipment supplied and installed shall have at least IP 55 Class protection rating.
 - q) An automatic lubrication system shall lubricate the main drive chains, step chains and handrail drive chains efficiently and economically.
 - r) The lower pit of all escalators shall be provided with a detection device, such as float sensor/switch, to stop the escalators if the pit is flooded. A drainage system by means of gravity shall be provided at the lower landing pit to discharge water that may be accumulated due to rain or washing. Alternatively, a sump and pump of suitable capacity shall be provided at the lower landing, to pump out water automatically. All piping shall have a minimum 50mm diameter with suitable wire gauze at the ends. The escalator drip pan at the lower landing shall also be removable for maintenance and cleaning of the discharge points. The discharge point(s) shall come with a grease inceptor(s) complying with ENV's requirements.
 - s) A weatherproof 13A switch socket outlet and protected permanent lighting shall be provided in the upper, lower landing pits and at the controller closet of the escalator.
 - t) Comb lights of minimum lighting levels of 50 lux, shall be provided. Comb lights of PUP escalators shall be connected to an Emergency Battery Operated Power Supply (EBOPS) situated in the escalator controller (ECP) closet

whereas for BI, the comb lights shall be connected to the bus interchange EPS/UPS supply.

- u) A display unit (with a protective cover) indicating the fault code shall be installed at an easily accessible and protected location on the handrail decking at the landing nearest to the control panel.
- v) Faults that do not require the attendance of the maintenance staff shall be easily identified to enable the operator to reset the escalator.
- w) Earth Leakage Relay Protection shall be provided.
- x) Additional requirements for Transit escalators:-
 - (i) The track system shall be provided with counter guards throughout the entire step band to prevent the uplifting of the steps and step chain rollers. For areas whereby counter guards cannot be installed, step hooks shall be provided.
 - (ii) The tracks wearing surfaces shall be a minimum 5mm thickness. This requirement is applicable to the step roller track and the chain roller track for both the passenger side and the return side. The wearing surface of the return track can be of 3mm thick subject to design reviews and acceptance by the Authority.
 - (iii) Handrails shall be of the “V” type cross section.
- y) Escalators installed at POBs shall be of outdoor type and suitable for use in local environmental conditions. The designs of these escalators shall be submitted to the Authority to demonstrate its suitability of use in the installation.

11.10.2 Energy Conservation Requirements

- a) An energy saving device to conserve energy by the reduction of speed (standby speed) when the escalator/passenger conveyor is operated at no load shall be provided. During an extended period of no load, the energy saving device shall also be able to reduce the speed from standby speed to stop (standby stop). Provision shall be made to allow the escalator/passenger conveyor to be operated without this energy saving device. In any operating mode the device must not cause abrupt change in speed or jerk. The device shall not cause harmonic feedback to the power supply system or emit electromagnetic interference to other systems.
- b) When the escalator is operating at no load, the quantum of energy saved with this device should not be less than 30% as compared to operation without this device.
- c) Piezo contact mat mounted underneath the landing floor plate or photo sensor installed at the newels end shall be used as the detective means for energy saving device. Other means of detection may be considered.
- d) Data and calculation shall be provided to substantiate energy savings on various escalator loadings.

11.10.3 Machine Rooms/Pits and Closets

- a) Controllers and other accessories such as incoming isolators, ITB's and switches shall be housed outside the truss, in wall recess/closet/room below the escalator or adjacent to the lower/upper landings. Location of the controller shall be kept within 10m of the escalator.
- b) The escalator/passenger conveyor controller shall be housed in an IP54 spray painted, 1.5mm thick galvanised sheet metal cabinet with hinged door, lockable with a dedicated key. The size of the controller cabinet shall be suitable for mounting into a wall recess/closet that will also be housing the incoming power supply isolator and ITB's. The wall recess/closet shall come with lockable full-louvered doors and the dimensions shall not be greater than 2700mm (wide) x 2400mm (high) x 750mm (deep).
- c) The machine pits and controllers wall recess/closet shall have appropriate ventilation to ensure that the temperature therein does not exceed 38°C.
- d) Escalator landings shall be provided with easily openable, hinged landing plates suitable for access to the drive mechanism. Landing plates and the combplates shall have a non-slip high wear resistant, aluminium surface that will facilitate sectional replacement. Lifting handles shall be provided to facilitate opening of the landing plate. Means, such as hydraulic/pneumatic cylinders, shall be provided so that the force required to lift the floorplate is not more than 200N.
- e) Corrosion resistant, oil tight drip pans of galvanised sheet of not less than 2.0mm thick shall be provided for the entire length of the truss and shall be of sufficient rigidity to support the weight of workmen. Drip pans shall be designed to collect and drain off both oil from the machines and water, which may enter through the landings, floor plates, exposed portions of escalators and passenger conveyors or from fire suppression systems. All gaps shall be properly sealed to prevent leakage. Means shall be provided to drain and collect any excess lubricating oil from the chains to removable container(s) at the lower landing machine pit for easy removal and cleaning.

11.10.4 Cable Requirements

- a) All cables used except those within enclosed closet or trunking/galvanised steel conduit shall be of the fire resistant/retardant type.
- b) All cables shall run in galvanised steel conduit or galvanised steel trunking. The steel conduit shall comply with SS100 and BS4568 Part I & II, Class 4. The steel trunking shall comply with SS249. All galvanising of cable support shall be in accordance to BS729 and BS4921. Compression glands for cables shall comply with BS6121. Flexible conduit used shall be enhanced low fire hazard, polyolefin covered galvanised steel conduit. All conduit outlets shall be bushed appropriately. All cable support connections including to all electrical fixtures shall be watertight.

11.10.5 Safety Requirements

- a) Three sides of each step/pallet shall be provided with yellow demarcation lines of at least 20mm wide, made of one homogenous polymer material and do not

emit toxic gas when burnt. The cleats shall be positively fastened to the tread board. Skirt brush guards of accepted design complying with EN 115 shall be provided along the skirt panel to enhance passenger safety.

- b) Emergency Stop Switch of the recessed, momentary pressure and emergency push button stop type with extended sleeve to protect against accidental operation shall be provided on each escalator and passenger conveyor. A minimum of one switch shall be located in conspicuous and accessible positions at the incline section/treadway as well as at the newel at both ends of the escalator/ passenger conveyor. The distance between the switches shall not exceed 15m and 40m for escalators and passenger conveyors respectively. The operation of any one of emergency stop switches shall disconnect electrical power to the drive mechanism and activate the brake(s). It shall not be possible to re-start the drive mechanism by the use of these switches. To prevent vandalism, a transparent cover marked 'STOP' shall be provided over these buttons. A self-resetting, audible warning alarm/bell shall be activated once the cover is lifted. The design of these covers shall be integrated with the escalator and subject to the acceptance of the Authority.
- c) Step and Skirt Safety Detection Devices shall be provided in escalator skirting panels in close proximity to the upper and lower comb plate tips, on the track system at the upper and lower curves and at 7.5m intervals along each escalator. Electrical power to the drive mechanism shall be disconnected and the brake(s) applied should any one of these devices be activated due to the skirt panels being forced away from the steps.
- d) A detection device shall be provided to stop the escalator/passenger conveyor in the event of unintentional reversal of direction from the pre-set direction of travel. The detection device shall directly detect the direction of the moving steps/step chains instead of indirect means such as directions of the motor/gear shaft or coupling.
- e) A missing step detection device shall be provided, which shall stop the escalator before the step opening appears on the passenger side of the escalator.
- f) Stainless steel surface comb plates with yellow coloured combs shall be provided at both landings.
- g) Directional traffic signs shall be provided on the right side of the newel at both landings of each stainless steel balustrade escalator/passenger conveyor. For glass balustrades, traffic signs shall be provided on the right and left inner deckings at both landings of each escalator/passenger conveyor. The traffic signs shall be LED type indicating a green arrow for "Enter", and a white bar against red back ground for "No Entry".

11.10.6 Corrosion Resistance And Material Requirements

Escalator components shall be protected against corrosion as follows:

Component	Protection
Truss, balustrade supports, floorplate and combplate supporting structure and backing	Hot-dipped galvanised, minimum thickness 85µm.
Handrail guides steel profiles/brackets	Stainless steel.

Component	Protection
Step chain	Special protection against dust, water, mechanical damage, etc during installation shall be provided.
Steps	Corrosion proof materials.
Floor plate infill	Corrosion proof materials.
All bolts, nuts, shims and other hardware	Stainless steel/sheradised.
Balustrade profiles, interior balustrade panels, skirt panels, outer cladding panels	2mm thick, high grade stainless steel.

11.11 Air-Conditioning And Mechanical Ventilation System

11.11.1 Pipe works

Pipework Materials

Pipework specification for the various services shall be in accordance with the Table 11.10.1.

Table 11.10.1 Pipework Materials

Chilled and Condenser Water Pipes, Feed and Expansion Pipes	Heavy gauge galvanised steel to EN 10255, Class C for pipes up to 150 mm nominal diameter, Heavy gauge seamless galvanised steel to EN 10255, Class B schedule 40 for pipes above 150 mm nominal diameter.
Condensate Pipe (for fan coil units and split units or PEU)	UPVC pipes.
Make-up Water Pipes, and Refrigerant Pipes	Hard drawn Copper pipes to EN 1057.

11.11.2 Sheet Metal Ductwork and Accessories

- a) All sheet metal ducting shall be constructed of hot-dipped galvanised steel sheet and conformed to SMACNA or DW/144 Specification for Sheet Metal Ductwork,

Medium Velocity/Pressure Air Systems. Application and usage of ductwork accessories such as flexible joints, flanged joints, sealants, gaskets, hangers & supports shall also comply with SMACNA or DW/144.

- b) Smoke purging system ductwork including the sealant, flexible connection, gasket and accessories, shall be constructed to high velocity/pressure classification of SMACNA or DW/144 and shall be suitable for high temperature operation at a temperature of 250°C for at least 2 hours.

11.11.3 Ductwork Insulation

- a) All air-conditioning system supply air, primary air and return air ductwork (including those running inside the return air plenum) shall be thermally insulated. External thermal insulation shall also be applied even though these ducts are provided with acoustic internal lining.
- b) All ductwork immediately upstream and downstream of AHUs shall be internally lined with 5m length of 50mm thick acoustic lining or equivalent sound attenuation.
- c) All fresh air, exhaust air, transfer air ducts within an air- conditioned area and all air-conditioning return air ductworks shall be externally insulated with minimum 25mm thick, minimum 32 kg/m³ density semi-rigid fibre glass board wrapped with a factory applied aluminium vapour barrier jacketing.
- d) All air conditioning supply ductwork shall be externally insulated with minimum 50 mm thick, minimum 32 kg/m³ density semi-rigid fibre glass board wrapped with a factory applied aluminium vapour barrier jacketing.
- e) All air conditioning ductworks/pre-treated fresh air ductworks exposed to the weather shall be insulated with minimum 50mm thick rigid closed cell, phenolic foam (fire retardant type) insulation and minimum 15mm thick cement plaster finished on chicken wire mesh with colour painting.

11.11.4 Pipe work Insulation

- a) All chilled water pipework, feed and expansion pipework, and condenser water pipework in air-conditioned spaces shall be insulated with a pre-insulated rigid type polyurethane (fire retardant type) sections with minimum 22 SWG galvanised steel sheet metal jacketing. The insulation shall be applied using one shot injection completely filling the annulus between service pipe and casing.
- b) All refrigerant and condensate pipeworks shall be insulated with a fire retardant, self-extinguishing, CFC free (ozone depletion potential of zero), flexible, black, closed cell, elastomeric nitrile rubber insulation with Class 1 surface flame spread to BS476 Part 7 1997 and Fire Propagation (Total Index of Performance (1) less than 12 and Sub Index (i) less than 6) to BS476 Part 6 1989. The insulation shall be encased in a metal jacket or trunking even though they are installed inside the ceiling void and concealed space.
- c) Thickness of the pipework insulation shall be as shown in Table 11.10.4.

Table 11.10.4 Pipework Insulation Thickness

Type of Piping System	Nominal Pipe Size	Minimum Thickness of Insulation (mm)
-----------------------	-------------------	--------------------------------------

	(mm)	
Chilled Water Pipework and Feed and Expansion Pipework	Up to 40 50 to 200 Above 200	25 40 50
Condensate Drain Pipework and Condenser Water Pipework (in air-conditioned space)	All	15
Refrigerant Pipework	Up to 25 Above 25	20 40

11.11.5 Air Filters

Provision of air filters for ECS shall comply with SS 554 requirements.

- a) Air handling units shall be fitted with a 50mm thick low efficiency, disposable prefilter conforming to ASHRAE 52.2, Minimum Efficiency Reporting Value (MERV) 6 rating and a 50mm thick secondary disposable filter conforming to ASHRAE 52.2, Minimum Efficiency Reporting Value (MERV) 13 rating.
- b) Fan coil units shall be fitted with a 25mm thick low efficiency, disposable type filter conforming to ASHRAE 52.2, Minimum Efficiency Reporting Value (MERV) 6 rating.

11.11.6 Air Curtain

- a) The air curtain shall be provided with either wall-hang or ceiling suspended mounting and interlock with the FCU / AHU.
- b) Air curtain shall have 2-speed fan (high, low and off) with a push-button switch provided in the unit.
- c) Air deflection vents/louvers shall be provided for adjusting the airflow direction.
- d) The effective velocity at the design point shall not be less than 2 m/s.
- e) 1 no. 13A switch socket outlet each for air curtain above automatic sliding door.

11.11.7 Fans

- a) The fans shall deliver the air volumes and pressures as specified when tested to the AMCA standard 210 or equivalent ISO and EN standards.
- b) The fans sound power levels shall be detailed in octave bands from tests carried out in accordance with AMCA standard 300 or equivalent ISO and EN standards.
- c) Fans with airflow rate larger than 1 m³/s shall be selected with a combined fan and motor efficiency of minimum 70%. The combined fan and motor efficiency shall be calculated using the following formula:

$$\text{Efficiency (\%)} = \frac{[\text{Airflow (m}^3/\text{s)} \times \text{Total Pressure (Pa)} \times 100\%]}{\text{Motor Power Input (kW)}}$$

- d) The fans shall be statically and dynamically balanced.
- e) Terminal box for the motor cables shall be made of galvanised steel and mounted on the fan casing with sufficient space for cable entry and termination. The terminal box cover shall be provided with gaskets to prevent ingress of dirt and moisture. Stud type terminals shall be provided for termination of cables.
- f) Motors for fans shall be of minimum Class F insulation and shall be rated for continuous operation in ambient temperature of 40°C and in humid air conditions up to 100% relative humidity.
- g) Flexible connectors shall be provided between the fan and the duct.
- h) The fans shall be supported by spring type vibration isolators as recommended by the manufacturer to prevent transmission of vibration to the structure.
- i) The fans accessories such as flanges, hanger brackets, bell mouths, etc. shall be provided by the fan manufacturer.
- j) All necessary brackets, hangers and threaded components, including bolts, nuts, inserts and washers shall be made of hot-dip galvanized steel to BS EN ISO 1461. Bolts, nuts, washers, fittings, flanges, etc. of different materials shall be suitably insulated to prevent galvanic corrosion.
- k) An air-tight access door shall be provided on the fan housing or the adjacent ductwork to allow convenient maintenance access for inspection or cleaning of the fan impeller and motor.
- l) Support beams, support legs, platforms, hangers, anchor bolts and vibration isolators for the proper installation of equipment and maintenance of equipment shall be designed. Sufficient numbers of permanently attached lifting eyes for on-site assembly and disassembly of fan units shall be provided.
- m) Fans for smoke control systems shall be suitable for operation in atmosphere of 250°C for 2 hours and shall also conform to the following:
 - i) Motors shall have minimum Class H insulation
 - ii) Motor winding shall be insulated to permit the motor operation at the design conditions for a period of not less than two hours in an air temperature of 250°C.
 - iii) Flexible connectors between the fan and the duct shall be same temperature and fire rating as that of the associated fan and ductwork system.

- iv) All finishes shall be factory-applied and shall be certified by the respective manufacturer that the finishing materials are capable of withstanding exposure to an air temperature of 250°C for a period of not less than two hours without producing smoke or toxic fumes.

11.11.8 Water-Cooled Chiller

- a) The performance of the chillers shall conform to ARI standards 550/590.
- b) Peak design load efficiency of the chillers shall be better than 0.65 kW per refrigeration ton when tested to the latest ARI standard 550/590 and specified design conditions for the chilled and condenser water temperatures and flow rates.
- c) When determining the capacity and configuration of the chillers, due consideration shall also be given to the safe, proper and efficient operation of the chillers during partial load and low load conditions.

11.11.9 Cooling Tower

- a) Cooling tower performance shall be tested in accordance with the Cooling Tower Institute (CTI) Acceptance Test Code ATC-105 or accepted equal by an independent party.
- b) Rating of cooling towers shall be based on ambient air with a wet bulb temperature of 27°C.
- c) Location of cooling towers shall comply with National Environment Agency's (NEA) requirements. Cooling towers shall discharge warm, moist air away from adjacent walls, windows and structures/buildings and fresh air intake grilles. Specially designed discharge ducts may be used to deflect the air from undesirable directions.
- d) The cooling towers shall be provided with an effective drift eliminator with a maximum drift loss of 0.002% (when tested to CTI or approved equal) of the total water delivered to the tower at design condition.
- e) Cooling tower water shall be correctly treated with a proven non-chemical water treatment system. The non-chemical water treatment system shall comply with the statutory requirements on standard plate and legionella bacteria counts and shall also be effective in controlling the water quality, scale formation and growth of micro-organisms, and prevent corrosion and fouling without the use of chemicals.
- f) Equalizing pipe shall be same size or larger than the supply/return pipe header.
- g) Manual throttling valves shall be provided to balance the hot water distribution to each cell of the cooling water.

11.11.10 Air Handling Unit (AHU)

- a) The performance of the AHU shall conform to ARI Standards 410 and 430.
- b) AHU drain pans shall be of double wall construction and fabricated of heavy gauge stainless steel (grade 316) sheets with adequate foam type insulation sandwiched in between to prevent condensation.

- c) Casing cabinet shall be of panel construction, double wall type packed with insulation between the walls. Casing framework shall be of modular pentapost double skin construction. The outer skin shall be fabricated from minimum 1.3mm thick hot-dip galvanized steel sheet while the inner skin shall be fabricated from minimum 0.8mm hot-dip galvanized steel sheet.
- d) The entire panel casing cabinet shall be self-supporting and shall be able to withstand a positive or negative pressure differential of 2500Pa. At 1800Pa differential, the casing shall be airtight and shall not deflect by more than 1/200 of span. All bolts, nuts, screws and washers shall be made of stainless steel.
- e) The AHU casing frame shall be completed with thermal break construction in order to avoid condensation.

11.12 Fire Sprinkler System

- a) The Fire Sprinkler System shall comprise the following for each station:
 - One sprinkler jockey pump and two main sprinkler pumps.
 - Sprinklers, pipework, valves, fittings and etc.
 - Electrical control panels, wirings, accessories and etc.
- b) The sprinkler control valve set(s), sprinkler pumps and control panel shall be housed in the fire pump room.

11.12.1 Sprinkler Heads

- a) Tools shall also be provided to facilitate removal of sprinkler heads.
- b) Sprinklers shall be of UL/FM standard or listed with BRE.
- c) Sprinkler heads shall be glass bulb type with temperature rating of 68°C and shall be colour coded according to the approved standards. In areas of above normal temperature, high temperature sprinklers suitable for the temperature condition shall be provided to meet the SCDF's requirements.
- d) Sprinklers shall be of conventional pattern designed to produce a spherical type of discharge with a portion of water being thrown upwards to the ceiling. Sprinkler shall be designed with universal deflector enabling the sprinkler to be installed in either the upright or pendant position. Where applicable, the sprinkler heads shall be fitted with water shields and/or protective guards of an approved type.
- e) Exposed sprinklers for areas with false ceiling such as shops, offices, corridors etc. shall be designed for use with pipework within the ceiling space and shall be installed complete with ceiling plate (rosette) flush to the false ceiling. Sprinklers shall be of standard chrome finish. Ceiling plates shall be chrome plated or finish to the acceptance of the S.O. 'Split type' demountable ceiling plate shall be used to enable changing of damaged ceiling without having to remove sprinkler head.
- f) Protective guards of approved type shall be fitted to each sprinkler head in the area where sprinklers are located less than 2 metres above floor level and where they are liable to accidental and mechanical damage. Sprinkler heads installed

in the escalator pits shall be fitted with protective guards. Where applicable or required, these sprinkler heads shall be of the side throw type.

- g) The Contractor shall ensure that the regulations in SS CP52, where applicable are complied with in his installation with regards to maximum and minimum spacing between sprinklers on range pipes and between adjacent rows of sprinklers, maximum distance of sprinklers from walls or partitions, maximum distance of sprinkler heads below ceiling or roofs, minimum horizontal distance of sprinklers from beams etc.
- h) Easily accessible flushing facilities shall be provided for each zone to discharge to the nearest drainage outlet. The Contractor shall co-ordinate with the Civil Contractors as to the location of the drainage outlets.

11.12.2 Sprinkler Control Valve Set, Electrically Supervised Gate Valve and Accessories

- a) Sprinkler control valves shall be supplied and installed. Each sprinkler control valve set shall comprise the following :
 - Main stop valve
 - Alarm valve
 - Alarm devices including water motor alarm gong, pressure switch, etc.
 - Facilities for testing to suit the SCDF and SS CP52 requirements
 - Glycerine-filled pressure gauges to indicate 'upstream' and 'downstream' system pressures
 - Electrically - supervised device for valve closures.
 - Other equipment as necessary
- b) The stop valves must be 'right handed' and the controlling wheels shall be clearly marked showing in which direction the wheels are to be turned to close the valves. There must be individual indicators which shall show whether the respective valves are open or shut. The stop valves controlling water supplies shall be secured open by individual pad-locked straps.
- c) The alarm valve shall be fixed on the main supply pipe immediately above the main stop valves. The alarm valves shall be of an approved type and shall have all necessary connections of the correct size for connections to glycerine-filled pressure gauges, water motor alarm, combined drain and test valve etc. The operating pressures of all pumps shall be engraved on bakelite and installed at the test rack.
- d) The electrically supervised gate valves shall be with integral limit switches.

11.12.3 Alarm Gong

- a) Water motor alarms of approved type shall be supplied and fitted close to the sprinkler control valve set. Each water motor alarm shall comprise a fire alarm gong with a turbine to operate whenever the alarm check valves are being operated. The water motor alarms shall be suitably mounted on the wall above the alarm valves and all pipe connections shall not be less than 20mm diameter. Each water motor alarm shall be arranged to drain through a non-ferrous fitting with an orifice. Drain lines shall be connected to water drain or sump pit in which the water will ultimately be discharged to surface water drains.

11.12.4 Pressure Switches

- a) Pressure switches shall be provided for the control of the pumps. They shall be of the approved type and in compliance with the requirements of the relevant standards and codes. Pressure switches shall have adjustable settings which shall be set to comply with the requirements of the relevant codes and standards for all pumps in a chart. The chart shall be made of Perspex complete with reverse colour screen printing and labels indicating clearly the pressure setting. The chart is to be located near the pressure switches.
- b) Settings of pressure switches shall be labelled for all pumps in a chart. The chart shall be made of perspex complete with reverse colour silk-screen printing and labels indicating clearly the pressure settings. The chart is to be located near to the pressure switches.

11.12.5 Flow Switches

- a) Flow switches shall be of paddle type and of approved type. The paddle shall be suitable for the pipe size installed. Flow switches shall be complete with addressable interfacing unit.
- b) The flow switch shall have a single pole double throw (SPDT) mechanism which makes or breaks the electric circuit when water flows. All components of the flow switch that come in contact with the water shall be made of copper alloy.
- c) Contacts shall be suitable for the working voltage and current of the circuits controlled, and shall be of silver or approved alloy.
- d) Adequate space shall be allowed above the pipework for the installation of flow switches.
- e) Flow switches, which shall be of the self-resetting type and shall be installed in accordance with the manufacturer's recommendations.
- f) Flow switches shall incorporate retards or time-delay devices to avoid false alarms due to surges.
- g) The electrical contact block shall be completely sealed from the water in the pipeline.
- h) Where flow switches are installed within ceiling spaces, the Contractor shall co-ordinate with the respective Civil Contractors and ensure that access panels are provided to facilitate maintenance of the flow switch. The location of each flow switch shall be clearly identified on the access panel. The flow switch interfacing module shall be provided with enclosure of IP rating 55.
- i) Test valves shall be installed immediately down stream of each flow switch to enable local testing. Short drainpipe shall be provided after each test valve and properly terminated with cap.

11.12.6 Pressure Gauges

- a) Glycerine-filled pressure gauges shall be provided. Pressure gauges shall be of minimum 100mm diameter, threaded chromium plated brass ring with heavy glass, bronze spring tube, precision movement and micrometer adjustment.

Pulsation dampeners, steel pipe fittings and shut off cocks of needle point globe type, all brass, rated for 1035kPa working pressure shall be provided. Pressure gauges shall be installed with gauge cocks mounted in a location where they can be easily read. Pressure gauges shall be complete with built-in compensators for fluctuation in external factors such as temperature, humidity and etc.

11.12.7 Flow Meter

- a) Flow meters with direct readings shall be provided for control valve installation. They shall be suitable for the system operating range. Data on flowrate and operating pressure shall be engraved on metal plate and installed near the equipment subject to the S.O.'s acceptance.

11.12.8 Sprinkler Tank

- a) The water storage tank for sprinkler (preferably RC construction) shall be of the overall size and capacity as shown on the Drawings provided by the Civil Contractor. The installation of the tank shall comply with the PUB requirements.
- b) The tank shall be water tight and free from leaks, wetness and dampness.
- c) The tank shall be rendered mosquito proof when installed.
- d) Control float valve shall be provided for control of incoming water to the sprinkler water storage tank.
- e) The tank shall be internally partitioned into two separate compartments. Each compartment shall be provided with one access manholes of minimum 600 mm x 600 mm with hinged covers provided under this Contract. The manhole shall be used for access into the water tank compartment and inspection and maintenance of the float valve. Edges of the manhole shall be properly finished smooth or trimmed. Floats for the float valves shall be fabricated from copper with all joints brazed.
- f) Cowl type vents of 100 mm diameter and overflow fittings shall be provided for each compartment.
- g) Holes for tapping pipe connections shall be machined out.
- h) The tank shall be provided with access cat ladders permanently fixed in place. The ladders shall be provided adjacently to the manholes and shall be non-corrosive type.
- i) Visual water level indicators, with the necessary levels and lettering neatly and clearly marked, shall be provided. High/low water level alarm switches shall be provided and these shall be wired back to the MAP. The indicators shall high level at the upper end and low level at the lower end. Visual water level indicators shall not be glass tube type.
- j) Anti-Vortex device for the sprinkler tank shall be incorporated so that the effective capacity can be maintained.
- k) The Contractor shall co-ordinated with the Civil Contractor and other Contractors to ensure that adequate clearance of minimum 1000 mm are provided all round the tank to facilitate erection, inspection and maintenance of the tank. The clearance at the top of the tank shall not less than 750 mm for

access to the top of the tank. The Contractor shall also co-ordinate with the other contractors to ensure that the access manholes or the cat ladders are not obstructed by other services.

- l) Overflow and warning pipes shall be provided. Flow switch for warning pipe shall be provided and to be wired to the MAP.
- m) Puddle flanges for connection shall be supplied by the Contractor and installed by the Civil Contractor.
- n) Civil Contractors shall provide the incoming water pipe up to the stop valve just outside the tank.
- o) Air vents and overflow fittings shall be provided under this Contract for each compartment.
- p) The ladders, concrete platforms hand railings and access doors shall be supplied and installed by the Civil Contractors.
- q) Visual water level indicators, with the necessary levels and lettering neatly and clearly marked, shall be provided under this Contract. The indicator shall show high level at the upper end and low level at the lower end. Visual water level indicators shall not be glass tube type. Electrode type high/low water level sensors shall be provided under this Contract and these shall be wired back to the pump control panels and MAP by the Contractor.
- r) Anti-vortex device for the sprinkler tank shall be incorporated under this Contract so that the effective capacity can be maximised.
- s) All pipe penetrations provided under this contract shall be complete with puddle flanges and cast in the tank wall.
- t) The Contractor shall co-ordinate with the Civil Contractors and other contractors to determine the pipes penetration through the tank wall and the position of the cat ladders and the concrete platforms so as to avoid any clashes with the fire protection system and to ensure that they are suitable for their intended purposes.
- u) All exposed opening for the tank shall be completed with insect screen under this Contract.

11.12.9 Sprinkler Breeching Inlets

- a) Breeching inlet shall be provided to enable the SCDF to pump water into the sprinkler system.
- b) The breeching inlets shall be approved by the local authorities and listed under the Product Listing Scheme.
- c) All fittings shall be on the external wall and enclosed in a glass-fronted stainless steel cabinet complying with the requirements of BS 5041 : Part 5. The breeching inlet shall be recessed. The Contractor shall co-ordinate with the Civil Contractors for them to provide the recess, access door and signages.
- d) The breeching inlet connection shall be electrically earthed and it shall be properly earthed to ground using properly sized copper tapes. The Contractor shall provide an independent earthing system. A weep hole or drain outlet shall be provided to drain off any residual water within the breeching inlet box. The

earthing continuity across pipe joint shall be maintained using copper tape with proper metal to metal contact. The maximum allowable earth impedance shall be less than 10 ohms.

- e) Caps for the breeching inlet shall be of approved brass type and held close by means of a spring lock with a sufficient length of stainless steel chain.

11.12.10 Pumps

- a) This part specifies the furnishing and installation of sprinkler, jockey pumps.
- b) Pumps shall be capable of achieving the nominal flow rate against the head of the system.
- c) The Contractor shall submit hydraulic calculation of the operating head based on the equipment selected and upon the characteristics of the pipework system actually installed.
- d) Calculations together with certified performance curves of the pumps with the operating range indicated shall be submitted to the S.O. for acceptance.
- e) Pumps shall be furnished by experienced manufacturers normally supplying this type of equipment, and who can show evidence of having furnished such equipment that has been in successful operation for at least five years.
- f) Pumps shall be listed by under the Product Listing Scheme.

11.12.10.1 Pump Construction

- a) Sprinkler pumps shall be of the centrifugal volute, constant speed, single stage, single end suction, base or frame mounted and flexible coupled to motor drive. The casing shall be arranged for easy removal of impeller, bearings and seals without dismantling connecting piping. Casing shall be provided with drain and vent cocks.
- b) Jockey pumps shall be of centrifugal type. The sprinkler jockey pumps shall have rated capacities not less than any normal leakage rate and not more than the flowrate when any one of the sprinkler is burst. They shall have discharge pressures sufficient to maintain the desired system pressure.
- c) The pump casings shall be of close-grain cast-iron accurately machined and assembled with metal to metal joint.
- d) The impellers shall be made of bronze and designed to give non-overloading characteristics over a large range of head variations. The impeller shall be statically and dynamically balanced. Impeller rings shall be of cast-iron and removable, secured from relative movement by stainless steel and rotation ring. The shaft shall be of machine ground stainless steel.
- e) Bearings shall be self-aligning, radial and thrust ball-type, grease lubricated and designed for not less than 100,000 hours average life. Bearings shall be of the silent type.
- f) Pump glands shall be packing seal type. Shaft sleeves shall be bronze removable type. Drain pipe shall be provided to drain any leakage's through the pump seal into the nearest floor waste or sump pit.
- g) Pumps shall be capable of running under conditions of zero or low 'draw-off' continuously without overheating. This shall be achieved by an automatic

bypass circuit arrangement i.e. an automatic pressure relief valve and pipe at the pump discharge side.

- h) The pumps shall be directly driven by a totally enclosed fan cooled motor. Motors shall be equipped with sleeve bearings and speed shall be compatible with pump speed and shall not exceed 2900 r.p.m.
- i) Flexible coupling shall be provided between the pump and motor, and shall be of the steel pin/rubber bush type, accurately aligned. It shall be noted that the coupling is required to reduce shock, excessive wear and tear to the bearings etc. and is not there to compensate for misalignment. The pin and bush coupling require the same accuracy of alignment as rigid couplings, and the Contractor shall demonstrate correct alignment.
- j) Removable hot-dip galvanised sheet metal coupling guard shall be provided.

11.12.10.2 Pump Base Plate and Plinth

- a) The pump and motor combination shall be mounted on a substantial machined baseplate of fabricated steel and a suitable inertia block and the complete unit mounted on a suitably reinforced concrete plinth with anti-vibration mounting. The concrete plinth of at least 150mm shall be provided by the Civil Contractors. The casting of the inertia block with concrete if required shall be provided under this Contract.
- b) The base depth shall be as recommended by the pump manufacturer for mass or rigidity, but shall not be less than 150mm.
- c) The inertia block shall be sized to obtain minimum 1:1 ratio (inertia block/equipment mass ratio). Thickness of the inertia block shall be at least 150mm and not exceeding 300mm. The inertia blocks shall support the pipework up to and including the first elbow before the vertical riser. The minimum total static deflection shall be 20mm.
- d) Holes for foundation bolts, or the bolts shall be cast into the block. Foundation bolts shall be painted with anti-rust primer before installation.
- e) Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflection during pump running.
- f) Spring-type isolators shall be free standing and laterally stable without any housing and complete with 6mm neoprene acoustical friction pads between the baseplate and support.
- g) All mountings shall have levelling bolts that must be rigidly bolted to the equipment.

11.12.10.3 Maintenance Facilities

- a) Pump installation shall be complete with adequate facilities for maintenance and future replacement of Plant. Lifting eyes shall be provided for pumps and motors.

11.12.10.4 Guards

- a) All moving parts of the pump and motor shall be adequately guarded by a wire mesh screen of sufficient strength to avoid distortion under normal usage.

11.12.10.5 Flexible Connectors

- a) Flexible connectors shall be used on the pump outlet and inlet.
- b) Flexible connectors shall be manufactured of multiple layers of nylon tyre cord fabric and neoprene both moulded and secured in hydraulic rubber presses. Steel wire or rings shall not be used as pressure reinforcement.
- c) Flexible connectors shall be manufactured with floating steel flanges recessed to lock the connector's raised face neoprene flanges.
- d) All connectors shall be rated at a minimum of 1.5 times of the working pressure of the system.
- e) All connections shall be made with flanged sphere properly pre-extended as recommended by the manufacturer to prevent additional elongation under pressure.

11.12.10.6 Automatic Pressure Relief Valve

- a) Each pump shall be provided with an automatic pressure relief valve set slightly below the shut-off pressure of the pump. It shall provide circulation of sufficient water to prevent the pump from overheating when operating with no discharge. Provisions shall be made for a discharge back to the sump. The relief valve shall be labelled with the setting pressure.
- b) When the jockey pumps have a shut-off pressure exceeding the working pressure of the fire protection equipment, a suitable relief valve shall be installed on the pump discharge to prevent damage to the fire protection system. An orifice plate shall be installed at the discharge pipe of the jockey pump.

11.12.10.7 Electric Motor for Fire Pumps

- a) The correct selection of the electric motors for the fire pumps shall be the responsibility of the Contractor.
- b) Motor rating shall be rated for continuous operation at the ambient temperature of 40°C. Motors shall be totally enclosed fan cooled type and motor insulation shall be BS 2757 class B or better.
- c) Motors shall be suitable for continuous operation on voltages within ±10% of the supply voltage. Motors above 2.2kW shall be three phase 400V, 50Hz. Motors up to and including 2.2kW shall be single phase 230V, 50Hz.
- d) Bearings shall be precision grade, anti-friction, deep grooved ball type and extra quiet.
- e) All motors shall be suitably earthed to meet SS CP5 requirements.

11.12.11 Fire Pump Control Panel

- a) The Contractor shall supply and install fire pump control panels.

- b) The fire pump control panel and the associated components, accessories, instruments and relays shall comply with British Standard Specifications, IEC or SS.
- c) The control panel shall be of the self-contained, metal clad, cubicle type with flush hinged doors lined with rubber gaskets for front access. Doors shall be provided with car type lockable handles with standardised key locks and 3 sets of keys. The panels shall be suitable either for floor or wall mounting. The panel shall be isolated before the door can be opened for access or maintenance purposes. Floor trunkings supported on C-Channels between the control panel and pump are strictly prohibited.
- d) LEDs shall be used to indicate various functions on the control panel. A test and selector switch and ammeter for each pump shall be included in the panel.
- e) The control system shall be capable of both manual and automatic operation of the installation.
- f) Manual/Off/Auto, manual duty pump selector and pressure switches, and start/stop push button shall be provided. A visual and audio alarm shall also be provided to raise an alarm when the pump is tripped.
- g) The panels shall comprise standardised items, enabling easy exchange or replacement of faulty equipment.
- h) There shall be no magnetic and thermal overload trips for the fire pumps.
- i) Any no-volt release mechanism must be of the automatic resetting type such that on restoration of the supply the motor can restart automatically.
- j) Each panel shall include an incoming section equipped with load switch and feeder-section furnished with HRC fuse rated to provide protection for the connected cables in accordance with the definition in SS CP5.
- k) HRC fuses must be capable of the following:
 - Protecting the cable connections to the motor.
 - Carrying the stalled current of the motor for a period of not less than 75% of the period when such a current would cause the motor windings to fail.
- l) Single line diagram complete with control circuitry shall be laminated and affixed to the interior of all door panels.

11.12.11.1 Motor Starters

- a) Motors up to and including 2.2kW shall have direct-on-line starter.
- b) Motors from 2.2kW up to and including 11kW shall have star-delta starters to limit the starting current so that it shall not exceed 2.5 times of full-load current of the motor.
- c) Motors above 11kW shall have automatic transformer starters to limit the starting current so that it will not exceed 1.5 times of full-load current of the motor. Taps of 50%, 65%, 80% and 100% of full-load voltage shall be provided for the automatic transformer starters. The starter circuit shall not have any tripping devices.
- d) Starters and contactors contained therein shall comply with the Singapore and/or British Standards and SS CP52. Starters shall be classed for intermittent

duty. Contactor type motor starters shall conform to BS 587 and BS 775:Part 2 and BS 5424:Part 1.

- e) The starters shall be housed in the appropriate control cabinet board and arranged for automatic and manual control as required. The starters shall have flush mounting START/STOP push buttons, 'on load' integral isolating switch mechanically interlocked with the access door, auxiliary contacts, red pilot lamp to indicate motor 'running' and control circuit fuses.
- f) All starters shall be of electrically held on pattern with no-volt release characteristics but shall not release until the voltage falls below 85% of nominal. Any no-volt release mechanism must be of the automatic resetting type and that on restoration of the supply the motor can restart automatically.
- g) All contactors shall comply with IEC 158, utilisation category AC-3.

11.12.11.2 Cabinet Construction

- a) The cabinet shall be of dead front type and manufactured from minimum 2mm thick electrogalvanised steel sheet using folded sections or angle iron bracing for rigidity of construction.
- b) The cabinet shall have adequate ventilation, double layer enclosure, IP rating 55, weatherproof and be dust, drip and vermin proof, and shall be at least rated to IP55. The construction shall be such that it allows for ready access to the interior of the cubicles for operation and maintenance purposes. The opening of a door or the withdrawing of a circuit breaker shall allow access to that compartment only. Continuous galvanised steel sheets shall be provided to completely separate adjacent cubicles or switchgear.
- c) The cabinet shall be provided with non-ferrous gland plates for the entry of all incoming and outgoing cables. The gland plates shall be drilled on site to suit each appropriate cable.
- d) Instruments, LED indicating lights, switches, etc. shall be mounted directly on a fixed fascia panel suitable stiffened to hold such items firmly in position under all conditions of operation.
- e) All sheet steel, angles and channel for construction of the panel shall be galvanised and epoxy coated to a minimum thickness of 60 microns.
- f) The front doors shall be electrically interlocked such that doors can only be opened after the power supply is isolated.
- g) Separate compartmentation for Sprinkler pumps and Hosereel pumps control panel.

11.12.11.3 Busbars

- a) The panels shall be provided with 3 phase tinned copper conductor busbars. All panels shall also be furnished with neutral (N) having the same rating as the phase busbars.
- b) Busbars shall be of equal size, rectangular HDHC copper section capable of carrying for 3 seconds a through-fault current equivalent to the prospective 3 phase short circuit level of 25 MVA.

- c) Current ratings shall comply with BS 158 and BS 159 for a temperature rise not exceeding 50°C. Phase indication shall be provided on all busbars.
- d) All connections in busbars shall be bolted or clamped with contact surfaces suitably prepared to prevent oxidation in service, and all through joints and contact parts shall be tinned before connection.
- e) All bolts shall be tightened with an even tension. Approved washer shall be used at all joints. Cadmium plated high tensile steel bolts with BSP threads and having approved cadmium plated lock nuts shall be used.
- f) A copper earthing bar shall be provided and installed at the base of the full length of the panel. A tee connection from the earthing bar shall project into each breaker compartment for automatic grounding of the chassis when the breaker is inserted into the compartment. The cross-sectional areas of these earthing bars shall be sized for fault currents for faults of negligible impedance in accordance with SS CP5.
- g) Sharp right angle bend and twisting of copper bars shall not be allowed.
- h) Minimum spacing between copper bars shall not be less than 60mm.
- i) All copper bars must be hard drawn and tinned and insulated coloured PVC sleeveings to indicate their respective phase.

11.12.11.4 Earthing

- a) All metal raceway (conduit / trunking / cable tray) systems, supports, cabinets, panels, equipment cases and motor frames shall be permanently, solidly and effectively grounded (earthed). Continuity of equipment grounding shall be maintained throughout the system. Ground clamps shall be approved type, specifically designed for grounding.
- b) Copper-clad strap metal is unacceptable for earthing or bonding purposes.
- c) All non-current carrying metal parts of electrical equipment installations shall be connected to the ground loop as required. These will include wireway, busways, raceways, switchgear enclosures, motor-control centre enclosures, pushbutton stations, motors and any other non-current carrying metal parts which may become energised by accidental contact with line electrical conductors.
- d) The grounding (earth continuity) system shall be fully tested in strict conformance with SS CP 5.

11.12.11.5 Instruments

- a) Instruments shall be suitable for flush mounting and shall have square or rectangular type face with moulded plastic escutcheons.
- b) The ammeters and voltmeters shall be of the moving coil type and shall have accuracy class of the instruments of 3 or better.
- c) The voltmeter shall be provided with a selector switch for reading the values of the 3 phases i.e. phase to phase, and phase to neutral voltages.

- d) The scales-width shall not be less than 240 angular degrees and the designation shall be in amperes or volts on matt-white plate. Anti-parallax and anti-reflecting types of platform/covers shall be used. Ampere meter shall have compressed scale to cater for motor starting where necessary.
- e) Hour-count meters shall be provided to measure the operating period of each individual pump.
- f) A minimum of 2 nos of anti-condensation heaters shall be installed inside the panel. The power rating of these heaters shall be equivalent to the power dissipated by the panel during normal operation. These heaters shall only be activated when the process system is shut down or inoperative.

11.12.11.6 Indicator Lights

- a) All indicator lights shall be of pilot light and shall be provided in duplicate. The pilot light when lighted shall be visible in lit rooms.
- b) Light Emitting Diode (LED) indicator (green) shall be provided to show that there is electrical supply available to the control panel and this shall be labelled 'MAINS SUPPLY ON'.
- c) LED indicator (colour to latest CP5 requirement) shall be provided to indicate clearly each phase of the electrical power supply for both incoming and outgoing and to indicate the status of each electric motor.
- d) LED indicator (orange) shall be provided to show the failure of any one phase of the electric power supply to the electric motor driven fire pump which shall be labelled 'Pump Fail'.
- e) LED Indicator (red) shall be provided to show that the pumps are not operating and shall be labelled 'Pump Stop'.
- f) LED indicator (green) shall be provided to show that the pumps are running and shall be labelled 'Pump Running'.

11.12.11.7 Relays

- a) Relays shall be of first grade, with continuously rated coils and contacts to suit voltages and currents concerned. Relay holders for 24 V DC and 230 V ac shall have different pin configurations and placed at a distance apart.
- b) Care shall be taken in the selection of relays with regard to the use of cables. The Contractor shall ensure that there is no possibility of cable insulation breakdown due to surge voltages which may occur when inductive circuits are opened and closed. If necessary, limiting devices shall be installed and connected.
- c) The phase failure relay shall be of the star-capacitor type, arranged to close its contacts in the event of failure of one or more phases under any condition.
- d) Time delay relays, shall be of synchronous motor type, with adjustable time setting up to five (5) minutes and instantaneous reset. The minimum setting shall be one (1) second.
- e) Earth leakage protective relays shall be of the instantaneous type with adjustable settings from 5% to 40% in 5% steps.

11.12.11.8 Nameplates

- a) Each circuit, equipment and instrument of the control panel as well as the control panel itself shall be clearly identified and designated according to its function. The nameplate shall be of white traffolite laminated white/black/white engraved with black lettering and affixed with stainless steel screws. Details of the labels shall subject to the S.O.'s Acceptance before fabrication.

11.12.11.9 Internal Wiring

- a) Wiring within the control panel shall be neatly arranged laced into forms and suitably clamped. All internal wiring shall be installed in wiring channels or conduits as far as possible. Exposed wiring shall be kept to a minimum but where necessary, the wires shall be formed into compact groups suitably spiral-bound together and properly supported. Non-metallic material is preferred for the channels or conduit. Adhesive cable supports shall be the high bond type and shall not be easily dislodged.
- b) All conductors shall be terminated with suitable pressure type terminal lugs of proper sizes for terminal studs at the terminal blocks or shall be terminated in a manner compatible with the terminals of the instruments. Terminal block shall be appropriately rated. Plug-in type of terminal blocks shall not be used.
- c) All conductors shall run continuously between terminal studs without splices or tape.
- d) All conductors shall be identified by colour coding and labelled at each termination using numbered ferrules with wire number to correspond with Contractor's circuit diagrams. Terminal strips shall also be clearly numbered to conform to the wiring diagram and they shall be provided for all incoming and outgoing cables. In addition, all cable termination's and component circuit references shall be properly labelled.
- e) Terminals shall be of the tunnel type of suitable size for the wire it is to accommodate. Terminals shall be installed in readily accessible positions.
- f) The conductor colour coding for all electrical system shall be in accordance with EMA and SS CP 5 requirements.

11.12.11.10 Switches

- a) Push button controls shall be of the momentary contact type, and suitable for current of 15 amperes at 230V ac.
- b) Key-operated switches shall be of a rotary type such that the key can only be removed in the normal position. Alternatively, a rotary selector switch may be used with an integral lock, the key of which shall only be removable in the normal position. Rotary switches, with shafts that wear off easily during operation, shall not be used.
- c) Toggle switches shall be of a two position switch of robust construction and have silver contacts having minimum rating of 5 amperes for 230V ac and 3 amperes for 30V DC.

11.12.12 Miscellaneous

- a) The Contractor shall supply and install the following in the pump room:

- Non-fading single line/control wiring diagram (endorsed by PE), etc., shall be framed in a non-reflective transparent plastic/glass board.
 - Operation / Maintenance instruction to be framed in a non-reflective transparent plastic/glass board.
- b) Fibreboards shall be transparent type and provided at the front and rear of each panel to prevent accidental contact with all live parts. Suitable protection shields shall also be provided at the rear of all front panels with lamps/instruments. Danger signs shall be provided on all protective shields and/or barriers. Carrying handles are to be provided for all removable covers.

11.12.13 Pump Controls

- a) The automatic control of the sprinkler pump sets shall provide for the complete system pipework to be pressurised at the adjustable pre-set level. When the system pressure falls, initially the jockey pump shall come into operation to bring the pressure to the required value and then stop when the high limit pressure is reached. Adjustable time delay shall be provided.
- b) If the system pressure continues to fall inspite of the jockey pump operating, the duty sprinkler pump shall come into operation when the pressure falls to another pre-set level. The jockey pump shall stop when the duty sprinkler pump or standby sprinkler pump come into operation. Once started the sprinkler pump shall run continuously until stopped manually.
- c) If the duty pump fails to operate, the standby pump shall also automatically come into operation. The pump shall continue to operate and shall not automatically cut-out until it is manually switched off.
- d) Suitable pressure switches and gauges complying with Clauses 11.10.3 and 11.10.5 shall be provided to activate the pumps and to monitor the system pressure.
- e) Means shall be provided for the sprinkler pumps to be set for lead-lag duty (with changeover) and for the standby pump to operate should the duty pump fail to function after a time lapse (adjustable) upon closing of the starting circuit.
- f) Light indicators showing the status of the pumps and the water level in the sprinkler water tank shall be provided on the sprinkler pump control panels and MAPs.
- g) The pumps shall be fully operational within 30 seconds after starting.

11.13 Analogue Addressable Automatic Fire Alarm System

11.13.1 General

- a) This section specifies the design, supply, and install, testing and commissioning of the electric fire alarm system.
- b) The fire alarm system shall comply strictly with the requirements of the FSSD and SS CP 10.
- c) The fire alarm system component shall comprise of the following:
- Micro-Processor Based Main Alarm Panel
 - Detectors

- Manual Call-points
 - Alarm Bells
 - Fire Zone Plan or mimic diagram
 - Batteries and chargers
 - Electrical wiring, conduits, trunking, accessories, and etc.
- d) The system shall operate on 24V DC supply and was designed to give an early visual and audible alarm in the event of fire when any of the manual call points are activated.
- e) The system must be protected against lightning and/or voltage surges.

11.13.2 Operational Requirement

Upon activation of the manual call point, the alarm signal shall be automatically transmitted directly to the Main Alarm Panel giving both visual and audible indication at the Main Alarm Panel.

11.13.3 Main Alarm Panel

11.13.3.1 Construction

- a) The Main Alarm Panel shall be wall mounted type and of weatherproof construction.
- b) The cabinet of the Main Alarm Panel shall be fabricated from minimum 16 SWG electro-galvanised steel sheet, epoxy powder coated (signal red in colour to BS 381c requirements) to a minimum thickness of 45 microns. All angles and channels shall also be electro-galvanised.
- c) The cabinet shall be fitted with a door with glass panel, which shall be locked. All alarm group indicators and associated switches, voltmeters, ammeters etc shall be visible behind the locked door without opening the door. The door shall be provided with appropriate hinges and lockset and shall not sag when opened, due to its own weight.
- d) The manufacturer's name, together with any other appropriate means of identification of the alarm system shall be clearly and permanently marked on the Main Alarm Panel. The above information shall include the type of board and the model number. All brand names, model nos. and other identifications of components shall be left intact to facilitate ease of replacement.
- e) The Main Alarm Panel shall be of solid state modular design and with capacity of increasing by 25% the number of zones, by simple addition of zone modules. All spare zones shall be indicated.

11.13.3.2 Equipment within Main Alarm Panel

The Main Alarm Panel and associated control and supervisory equipment shall as a minimum, consist of the following items:-

- Alarm group or zone facilities.
- Individual reset switches per indicator.
- Facilities for testing and maintenance in accordance with the requirements of the FSSD.

- Battery test facilities with voltmeter and ammeter.
- Battery test switch.
- Audible fault alarm.
- Audible fault isolation switch.
- Lamp test button.
- Indications for mains power supply on.
- Indications for mains power failure.
- Alarm / Fault acknowledge.
- Reset buttons.
- Trickle / Boost charge.
- Indications for charger failure.

11.13.3.3 Precautions against failure

- a) A distinct visual and audible signal shall be given at the Main Alarm Panel in the event of the following:-
 - Failure or disconnection of the normal power supply.
 - Failure or disconnection of the standby power supply.
 - Failure or disconnection of the battery.
 - Failure or disconnection of the battery charging equipment.
 - Failure or disconnection of any of the leads to alarm bells.
 - Removal of any zone card.
- b) The audible signal used for giving fault warning shall be distinctive and of a different character from the audible fire alarm. Provision shall be made for cancelling the audible signal only. Where such provision is made, the removal of the fault shall automatically reset the audible fault warning circuit or cause the audible fault warning to respond until silenced by the manual operation of a biased switch or other device fulfilling the same function.

11.13.3.4 Alarm group or zone testing

- a) The switches, which shall preferably be of the push button type, and indicating facilities listed below shall be provided for each alarm group or zone. Means shall be provided to enable each switch or indicator to be readily identified; a common identification of the switch positions on the front of the Panel is acceptable.
 - Alarm Indicator- A red indicator designated 'alarm' for each zone or group which indicates on alarm only. Two bulbs are to be provided per indicator.
 - Fault indicator- An amber indicator designated 'fault' for each zone or group, which indicates on fault only. Two bulbs are to be provided per indicator.
 - Inhibit indicator- A green indicator designated 'inhibit' for each zone or group, which indicates on inhibition only. Two bulbs are to be provided per indicator.

- Alarm test:- Test facilities to simulate the action of the manual call-point in the alarm condition for each group or zone.
 - Fault test:- Test facilities to produce a circuit fault condition in the supervisory circuit of the wiring to the manual call-points. The fault test facilities shall simulate also both the positive to earth and negative to earth fault conditions.
 - Inhibition facility:- An alarm group or zone inhibition switch clearly designated 'inhibited' to disconnect each individual alarm group or zone from the Panel common circuitry. Operation of the switch shall prevent the alarm group from initiating either alarm or fault signals but shall not impair the normal functioning of any other alarm groups or zones associated with the Main Alarm Panel alarm.
- b) A common indicator designated 'group inhibited' shall be lighted on the Panel to show when any group is inhibited; the particular group inhibited being indicated by the position and labelling of the 'inhibited' switch.
 - c) The alarm and fault signals for each alarm group or zone shall be latched on at the existing Main Alarm Panel. The panel shall be reset after the alarm or fault condition has been cleared. Different audible alarms shall be provided to differentiate between that for "Fault" and for "Alarm".
 - d) When the audible signal is silenced by manual operation of a silence or acknowledge switch, any flashing signal then existent shall be replaced by a steady signal.
 - e) All indicators shall be long-life low quiescent current LED's (light emitting diodes).

11.13.3.5 Power

- a) The source of electricity supply for the alarm system shall not exceed 24V DC. In no case shall the voltage be less than 6V.
- b) The power supply equipment for the fire alarm system shall be exclusive to the alarm system. The supply shall be in the form of storage batteries designed for float charge and maintained by a continuous constant voltage charger.
- c) An approved self-resetting current-limiting device shall be installed in the circuit between the battery and the system, and such device shall be located at or adjacent to the battery location.

11.13.3.6 Battery charger and capacity

- a) A battery charger of the appropriate type and rating shall keep the storage batteries under constant voltage charge. The charger shall incorporate automatic control features with output designed to charge and maintain the cells within the limits specified by the battery manufacturer, taking into account any quiescent load imposed by the associated system. The charger shall be connected to a separate circuit with a switch that shall be satisfactorily labelled to indicate that it controls the fire alarm system. Fault warning shall be given in the event of failure of the main supply or of the charger. The charger shall also be designed to provide for a short duration boost charge.

- b) An isolating switch to interrupt the battery charger 'mains' supply shall be provided adjacent to the charger. This switch shall be within the cabinet when the charger is fitted in the Main Alarm Panel and the condition of the 'mains on' shall be indicated by a LED.
- c) The storage batteries shall be heavy duty, long-life, sealed and maintenance free and housed in a well-ventilated, dust and vermin-proof enclosure.
- d) The capacity of the storage battery used to energise the alarm system shall be such that in the event of mains failure, the battery is capable of maintaining the system in normal working condition to comply with SS CP 10. Thereafter it shall be capable of supplying an additional load, resulting from an alarm originating in two separate alarm groups for a period of half an hour. In addition it shall be capable of supplying the full emergency evacuation alarm load for a period of at least 10 minutes. The Contractor shall submit detailed calculations to justify the capacity of the battery and the battery charger. A switch for disconnection of the battery shall be provided.

11.13.3.7 Identification and labelling

- a) Each alarm zone indicator, test switch and control etc on the Main Alarm Panel shall be clearly identified by the use of engraved laminated labels. The zone number and area, room served shall also be identified.

11.13.3.8 Fire Zone Plan

- a) The Contractor shall supply and install a fire zone plan for the development. The fire zone plan shall indicate the layout with the fire alarm zone, call-point locations, locations of all fire extinguishers, hosereels, etc clearly.
- b) The fire zone plan shall be of perspex sheet, etched on the reverse side and affixed onto the wall with stainless steel screws. The plan shall be framed besides the Main Alarm Panel.
- c) The fire zone plan shall not fade on exposure to sunlight and weather and shall be suitable for installation in an outdoor location.
- d) The fire zone plan shall be reviewed and approved by the Superintending Officer before fabrication.

11.13.4 Fire Alarm Bell

- a) All alarm bells shall be iron clad and shall be of weatherproof construction and installation.
- b) It shall operate on 24V DC and shall be 150mm round red gong pattern suitable for 20mm conduit entry except otherwise stated.
- c) Bells should be labelled 'FIRE ALARM' in English.
- d) Bell circuits shall be 'interleaved' and separately fused at the control unit.
- e) The alarm bells shall be mounted at a height of 2250mm above the finished floor level or otherwise as directed by the Superintending Officer.
- f) The sound level at 3m away shall be a minimum 85 dBA.

- g) The alarm bells shall be wired such that it will be activated automatically upon activation of the manual call-point.
- h) The alarm bell shall be UL listed and/or approved by other international approval bodies.

11.13.5 Manual Call Point

- a) Manual call point shall be arranged to operate automatically upon breaking of the glass and shall comply with the requirements of BS 5364:Part 1 and acceptable to the FSSD. The cover shall be locked in position with a special key and the glass panel shall be clipped firmly into place. The unit shall be of pleasing appearance and styling and finish enamelled red. The words: "In case of Fire, Break Glass" shall be included. The voltage and current ratings of the contacts shall be marked within the unit.
- b) Contacts shall be of silver or approved non-deteriorating alloy for normally closed alarm system. A concealed 'test' device shall be included.
- c) Mounting height of units shall be at 1400mm above finished floor level.
- d) Manual call-points installed outdoors shall be of weatherproof construction and installation and shall be at least rated to IP55. Those installed within the public area shall be vandal-proof.

11.14 Fire Hosereel & Hydrant System

11.14.1 General

The construction and installation shall comply with CP 29, "Fire Hydrant Systems and Hosereel" and comply with all regulations and requirements of the Fire Services Safety Department (FSSD) and Building Control Authority (BCA).

11.14.2 Hosereel System

- a) The hosereels shall be of the swing type complete with all accessories including stop valves, reels, hose guides, shut-off nozzle assembly and hosereel cabinet. Hosereel shall be factory tested against water leakage after assembly at a test pressure of 13.8 bars (200 psi) for a duration of 30 seconds for each unit. Test reports shall be submitted to the S.O., before the delivery of the hosereels to Site. All fees required for such tests etc. to be carried out shall be deemed to have been included in the Works.
- b) Rubber Hose : The rubber hose shall be 25mm internal diameter hose and shall have a minimum working pressure of 7 bars (100 psi) and shall be of the non-kinking type. Rubber hoses shall be manufactured with an inner tube, a reinforcement of braided textile lining and an abrasion resistance rubber cover. The reinforcement shall consist of a single rayon braid or a double braid of cotton complying with BS 3169:1981 or AS 1221:1983 "Rubber reel hose for fire fighting purposes".
- c) Stop-Valve : A 25mm stop valve of a type approved by Authority shall be provided for the connection of the hosereel to the water supply system. An

indication of the open and shut positions shall be fixed or permanently marked on the wheel of the valve. The body of the valve shall be marked with a directional arrow indicating the direction of flow through the valve. The water connection shall be such that through the rubber hose, it shall permit the full flow of water to the hose without physical leakage during any rotation of the reel.

- d) Shut-off Nozzle : A shut-off nozzle assembly shall be provided in accordance with the following requirements:
 - The assembly shall be constructed of a corrosion resistant material of adequate strength.
 - The assembly shall be capable of easy operation.
 - The assembly shall be permanently marked to indicate the open and shut position of the nozzle.
 - The internal surface of the nozzle shall be finished to provide a smooth surface.
 - The internal diameter of the outlet shall be 6.5 mm plus or minus 0.075 mm.
- e) Reels shall be of rigid construction using 2.0mm pressed steel and finished in Signal Red enamel paint. It shall rotate freely on leak-proof bearings and be fitted with pivoted nylon rollers to allow easy run-out of the hose. It shall extend not more than 350 mm from the mounting surface and shall have an overall diameter not greater than 760 mm.
- f) The reel diameter of the inner core on which the hose is wound shall be not less than 2000mm. When the full length of the hose is coiled on the reel without the use of abnormal tension, the rims of the side plates of the hosereel shall project at least 10 mm beyond the external diameter of the coiled hose at any point.
- g) Hosereel Cabinet :
 - Hosereels in the public area shall be housed within galvanised steel cabinet. The door of the hosereel cabinet shall include the following features:
 - Fastened only by means of spring lock.
 - The door shall be labelled “Hosereel” and the label shall be submitted for acceptance.
- h) Markings : Every hosereel shall be marked with the following information:
 - The manufacturer's name, trade name or mark, or the name, trades name or mark of the responsible vendor and their addresses.
 - Instructions for operation and use which shall include inter-alia the following:-
 - Turn on stop valve or release nozzle.
 - Run out hose.
 - Turn on water at nozzle.
 - The hose shall be fully discharged before winding it onto the reel.
 - The year of manufacture.
 - Test pressure in bar.

11.14.3 Hydrant System

- a) Hydrant outlets shall be twin-head type with the outlet size for 65mm diameter and complete with minimum 100mm-diameter pillar.
- b) Hydrant material shall be of gunmetal construction.
- c) Outlets shall be provided with protective standard caps of cast iron or gunmetal and attached to the standpipe by chains.
- d) Suitable size of control valve shall be supplied and installed to each hydrant. The valve shall be able to open and close from the surface of the ground level.
- e) Hydrants together with valve pit shall be installed on concrete plinths with size of 1400mm x 700mm x 100mm thick.
- f) Valve pits should be of adequate size and readily accessible for inspection, operation, testing, maintenance and removal of equipment contained therein. They should be so constructed and arranged as to properly protect the installed equipment from ground movement and accumulation of water.
- g) Cast in-situ or precast concrete, with or without reinforcement, or brick (depending on soil conditions and size of pit) are appropriate materials for construction of valve pits. Where the water level is low, and the soil is porous, crushed stone or gravel may be used for the floor of the pit.
- h) For Fire hydrants sited in roadways, care shall be taken that the pits and covers are capable of bearing the heaviest vehicle, which may use the roadways.

11.14.4 Water Supply

Fire Hosereel and Hydrant water shall be direct feed from PUB water mains wherever possible.

11.14.5 Piping and Installation

Refer to section 11.16, "Pipework" section in this Specification.

11.15 Portable Fire Extinguishers

11.15.1 General

- a) Portable fire extinguishers shall conform to the relevant Singapore Standard currently in force and approved for use by all relevant local authorities.
- b) The type, location and quantity of portable fire extinguishers to be installed shall be as shown on the Drawings.
- c) Every fire extinguisher shall be manufactured to comply with the Local codes and shall be approved for use by the FSSD and Singapore Standard CP 55 – Use and Maintenance of Portable Fire Extinguishers
- d) Fire extinguishers shall be filled with appropriate fire extinguishing agents under pressure and shall be labelled in accordance to the classification of fire hazard as well as weights of the extinguishing agent.
- e) All fittings and safety features necessary for the fire extinguisher to be approved for use as a complete unit shall be incorporated.

- f) Fire extinguishers mounted in public area shall be housed within galvanised steel cabinet.

11.15.2 Installation

- a) Each fire extinguisher shall be suitably installed for upright instantaneous operation.
- b) For units to be wall mounted, it shall be mounted 1.2 meter above the floor level. Suitable hangers or brackets of corrosion resisting material shall be provided.
- c) Instructions shall be labelled and displayed permanently on the body of the extinguishers showing clearly the necessary operation, maintenance and re-loading equipment.
- d) Locations of all fire extinguishers shall tally with the approved architectural fire plans or as directed by the Architect.

11.16 Pipework

11.16.1 General

- a) This section specifies the design, supply, installation, testing and commissioning of pipework for the sprinklers, hosereels, and automatic inert gas total flooding systems.
- b) All pipework delivered to site shall be new, cleaned, capped, deburred, free from scale, rust, grease and colour banded to identify different grade. All black steel pipes and fittings shall be cleaned and thoroughly wire brushed and prime coated prior to installation. All galvanised steel pipes and fittings shall be cleaned and prime coated prior to installation.
- c) Pipework shall be installed with correct fall to ensure adequate venting and draining.
- d) Pipework installed in trenches, ducts, voids and inaccessible places shall have welded joints except where screwed or flanged joints are necessary for connecting to valves etc. The pipework shall be inspected and tested by the S.O. or representative prior to concealment.
- e) No pipe joints or fittings shall be permitted within the thickness of walls or floors etc.
- f) All exposed pipeworks shall be installed so that minimum clearance of 100mm is left between the outside of the pipe and the nearest wall equipment surface and minimum 100mm from ceiling or slab. Pipes shall be run at a minimum distance apart to enable them to be individually painted.
- g) The gap between pipes sleeve and pipe shall be fire-stopped using approved fire-stopping material having fire resistance not less than required for fire compartment wall.
- h) All pipework shall be installed in accordance with the relevant standards, codes and to the approval of the local authorities. The Contractor shall check and ensure that the design meets the requirements of the local authorities having jurisdiction without additional cost.

- i) The Contractor shall submit manufacturer's printed installation, operation and maintenance instructions, consisting of installation and operation procedures, detailed parts list, recommended spare parts list, and complete maintenance procedure of all valves and piping accessories.
- j) The Contractor shall submit pipe support and anchor details.
- k) The Contractor shall submit pipe testing and cleaning procedures for S.O.'s acceptance.
- l) No pipe shall be installed at low level across route of egress or maintenance access routes causing obstruction to access.
- m) All angle support brackets installed at low level shall be padded and warning signs shall be provided.

11.16.2 Piping Installation

- a) All pipes shall be installed parallel to walls, clear of obstructions, preserving head room and keeping passageways clear.
- b) All pipes shall be cut in a neat and workman like manner without damage to the pipe. Cutting shall be done with an approved type mechanical cutter. The Contractor shall use wheel cutters where practicable. Pipe ends shall be reamed to remove burrs. Cutting of pipes and fittings with gas torch is not acceptable.
- c) Welding of pipes shall only be undertaken by welders holding a minimum National Trade Certificate - Two in Welding issued by Institute of Technical Education or its predecessor or equivalent acceptable by the S.O. The Contractor shall submit qualification of all welders who will undertake the welding work of this Contract.
- d) All pipes shall be so installed that the system can be thoroughly drained. Sprinkler pipework shall be arranged to drain to the installation drain valve. Auxiliary drain valves shall be provided for the trapped section of the system.
- e) Automatic air vents shall be provided at each high point of each water pipe line and where necessary, it shall be complete with isolating cock.
- f) All pipes shall be stored with closed ends, which shall not be opened until erection. All pipes shall be flushed to prevent foreign material being left in the pipe.
- g) As soon as pipe lines have been installed openings shall be covered to prevent entrance of debris and materials that would obstruct the pipes. Covers shall be left in place until necessary for completion of Works.
- h) Supports shall be attached only to structural framing members. Where supports are required between structural framing members, a suitable intermediate metal frame shall be provided.
- i) Screwed joints shall be made with tapered threads properly cut. Joints shall be made with Polytetra-fluoroethylene tape, or other approved thread joint compound applied to the male threads only. Not more than three threads shall show after the joint is made up. However, the thread shall not be cut too deep where leakage might occur.
- j) Flanges and unions shall be faced true and provided with approved gasket, and made square and tight. Union or flange joints shall be provided in each pipe immediately preceding the connection to each piece or equipment or material

requiring maintenance, such as pumps, control valves, and other similar items. Gaskets shall conform to ANSI B16.21 and ASTM D2000.

- k) Pipe grooving and coupling shall be installed in accordance with the manufacturer's recommendations. The pipe grooving shall be formed and not cut which weaken the pipe joint and for pipe.
- l) Valves installed in horizontal pipes with stems horizontal or above shall have isolation valves at any points indicated or required for draining, isolation, or sectionalising purposes.
- m) Pipes connected to equipment shall be supported independently such that the equipment is not stressed by piping weight or expansion.
- n) Unions or flanges shall be provided to facilitate maintenance, repair and replacement.
- o) Drawn bends shall not be used unless otherwise accepted by the S.O..
- p) Pipes pass through a building expansion joint, and/or are subjected to movement, approved flexible connections shall be provided to eliminate any stress.
- q) All drainage pipework shall be installed plumb, level or true to the gradient and shall be neatly grouped with the minimum number of crossovers and adequate provision for venting, expansion, contraction and movement. Pipework shall be substantially supported to the acceptance of the S.O., and shall not be located less than 100mm above finished floor levels. Adequate clearances shall be maintained from all other services and from the building structure.

11.16.3 Installation of Pipe Hangers and Supports

- a) All necessary hangers and supports, including rods, angles, channels and plates shall be subject to the S.O.'s Acceptance.
- b) Vertical piping shall be guided or supported in the centre of each mains with approved steel brackets to prevent swaying, sagging, vibration and resonance. Strains shall be avoided that may cause pipeworks to snake or buckle between supports or anchors.
- c) Anchors and guides shall be provided for all horizontal and vertical piping for proper control of thermal movement, this is required to prevent undue strain on branches, provide proper performance of expansion loops and to avoid overloading of hangers and supports.
- d) Spacing of supports shall not exceed the centres given in the table below unless otherwise agreed by the S.O..

Piping Materials	Nominal (mm)	Bore	Centre of Support (m)	
			Vertical	Horizontal
Steel pipe	15 - 40		2.5	1.8
	50		2.7	1.8
	65 - 80		3.5	3.5
	100		4.0	4.0
	150		4.5	4.5
	200		5.0	5.0

- e) Pipe hangers shall be placed not more than 600mm from each change of direction where possible.

- f) All hangers and supports shall be of hot-dipped galvanised mild steel of adequate dimensions and approved design. The pipe shall be restrained to prevent movement by a horizontal thrust when flexible fittings are used. However, threaded components, including bolts, nuts, inserts and washers shall be of sheradised mild steel to BS 7371 Part 8, Class S1.

11.16.4 Protection of Pipeworks

All piping work shall be protected during and at the end of each day's work to prevent entrance of moisture or dirt or contamination of the systems.

11.16.5 Pipework Materials

Pipework material specification for the fire protection system shall be as follows:

Hosereel pipes	Heavy gauge copper, BS EN 1057 for direct feed from PUB mains Galvanised steel, BS EN 10255 for pump feed
Sprinkler pipes	Black steel ASTM A53 or Black steel, BS EN 10255 (diameter 25mm to 150mm) or Black steel, ASTM, A53, Schedule 40 (diameter 200mm and larger)
Air vent pipework	Copper BS EN 1057 or Galvanised ASTM A53 and others, Schedule 40
Underground pipes	Ductile iron cement lined BS/EN 545 Class K12

11.16.6 Pipe Joints

- a) For galvanised steel pipework, all joints up to and including 65mm diameter shall be made by means of screwed socketed connections. Pipes of 80mm diameter and above shall be joined by means of mechanical groove coupling.
- b) All pipeworks within pump rooms shall be of flanged joints. Joints shall not be closer than 3000mm except where necessitated by fittings. Flanges shall be wrought iron or annealed steel, machined full face, suitable for the working pressures to which they will be subjected. Flanges shall conformed to the relevant ANSI Standard and pressure rating.

11.16.7 Pipe Fittings

- a) Pipe fittings shall be provided as specified in the following table and conform to the requirements of the relevant standards for the various pipe materials.

Piping Materials	Specification of Fittings
Black mild steel	Galvanised malleable iron tube to BS 1387 screwed fittings to BS 143
Copper BS EN1057	Copper fittings to BS EN1254

Piping Materials	Specification of Fittings
Ductile iron cement lined BS/EN545 Class K12	Ductile iron BS EN 545, Class K12
Galvanised steel pipe to ASTM A106 Schedule, 80 Grade B	2000lb Class Galvanised forged steel iron screwed fittings
Galvanised steel pipe to ASTM A106/A53 seamless Schedule 40, Grade B	Class 300 Malleable iron screwed fittings

- b) Eccentric reducing sockets shall be used where a reduction in pipe size is required, to ensure proper drainage or elimination of air pockets and at the pump suction and outlet. Concentric reducing sockets shall be used for vertical pipes only.
- c) Long sweep bends shall be used in preference to round elbow bends whenever practicable. Mitre elbows shall not be used.
- d) Long radius elbow and sweep or 'pitcher' tees shall be used on all changes of direction. Bends and off-sets formed by welding together of segmented pieces shall not be used.
- e) Pipe fittings for joining pipes of 80mm diameter and larger shall be standard mechanical groove coupling. Pipe fitting for joining pipes of 65mm diameter and smaller shall be of screwed socket connection. Welding for such shall not be allowed unless accepted by the S.O..

11.16.8 Gaskets

- a) Gaskets shall be suitable for temperature, service and pressure of system, installed in accordance with manufacturer's recommendations. All gaskets for flanged joints shall be of one-piece ring, 1.5mm thick and neoprene.
- b) Insulating gaskets, washers and sleeves shall be provided for flanged joints in between dissimilar metals

11.16.9 Vertical and Riser Pipe Isolation

- a) Risers shall be suspended from or supported by hangers or mountings. In general, all riser pipes in duct shafts shall be resiliently suspended at the top of the pipe duct shafts. "Duck foot" supports for pipe elbows connecting to equipment shall rest on resilient mounts having minimum deflection not less than that of the isolators for the respective equipment.
- b) In general, all resilient mounts and hangers shall have a minimum static deflection of 20mm.

11.16.10 Horizontal Pipe Isolation

- a) Vibration hangers shall be provided generally for pipes inside the pump room.
- b) Minimum static deflection of hangers for the first three supports for pipes from equipment shall be as follows :-

Pipe Sizes(mm)	Minimum Static Deflection (mm)
Up to 75	20
Up to 150	38

All other hangers and mounts shall have a minimum of 20mm deflection.

11.16.11 Sleeves and Covers

- a) The Contractor shall co-ordinate with the Civil Contractors on the location and size of pipe sleeves whom will be providing and installing them. Pipe sleeves shall be provided where pipes pass through walls, floors etc. All sleeves shall be of short pipe lengths and galvanised. Pipe sleeves fitted in walls or partitions shall be flush with the plaster or other surface finish. Pipe sleeves fitted in floors shall generally end 25mm above the finished floor level, except in plant rooms and other areas where 'wet floors' are expected whereby the sleeves shall end 50mm above the finished floor level.
- b) All sleeves shall be of sufficient size to allow free movement of pipes. The gap between pipe and its sleeve shall be firmly packed with fibreglass blanket material. However, for pipes/sleeves passing through fire barriers, the gap between the pipes and sleeves shall be packed with approved type fire resistance material of at least equal fire rating to the fire barriers. The ends of the sleeves shall be caulked with non-hardening mastic to the S.O.'s acceptance. The fibreglass, fire resistance materials or non-hardening mastic shall be provided and installed by the Contractor.
- c) Contractor's attention is drawn to the vertical pipe ducts. At floor levels in the building, the pipe ducts shall have floor slab and where pipes through these slabs sleeves shall be provided.
- d) Brass or copper plates, chrome plated in public areas, shall be slipped over pipes before installation, to cover raw ends of pipe sleeves. Split cover plates will not be accepted. The 20mm projection of pipe sleeves may be reduced after all construction work has been finished such that the cover plates attached to the finished work in an acceptable manner.

11.16.12 Stainless Steel Bellow Expansion Joints

Stainless steel expansion joints shall be provided wherever expansion loops or changes in direction of pipework (for allowing expansion and contraction of pipework) is not feasible.

11.16.13 Pipe Anchors

- a) Anchors shall be positioned in association with pipework changes in direction and at expansion joints and loops so as to absorb stresses due to pipework expansion and internal pressure by transmission of such forces to the ground or structure at appropriate points.
- b) Anchors shall be constructed to withstand the hanger thrust during piping hydraulic pressure testing.
- c) All details and sizes of anchors shall be submitted for S.O.'s acceptance prior to installation.

11.16.14 Valves, Cocks etc.

- a) Valves and cocks shall be provided for the proper operation of the system.

- b) All valves, cocks etc. shall comply with the requirements of PUB and the relevant code of practices for fire protection system.
- c) Service isolating valves shall be fitted to all items of Plant including tanks, pumps etc.
- d) All valves shall be suitable for the working and test pressure of the system concerned.
- e) Valves shall be fitted in accessible positions for operation and repair. The connection between each valve and the adjacent equipment shall be made either with a union or flange for ease of dismantling.
- f) The Contractor shall co-ordinate with the Civil Contractors for their provision of access openings for flow switches and valves installed above ceilings
- g) Regulating valves shall be of globe type for fitting on branch pipes, by-passes etc. and where regulation of flow is required for balancing the systems.
- h) All valves shall be of heavy duty type suitable for the working hydraulic pressure stated and installed with the valve stems truly vertical or horizontal.
- i) All valves shall be arranged so that clockwise rotation of the spindle closes the valve. Handwheels shall have cast-on direction arrows. Where installed at changes in direction of the pipework, angle valves are preferred to straight through valves and bends.
- j) All valves except those for the hose reel shall be secured in open/close position with leather strap and padlock after erection. The Contractor shall provide two sets of common keys for all padlock. Open/close position indicators shall be provided for the valves as per the requirements of the relevant codes and standards.
- k) Isolating valves up to and including 50mm bore shall be of copper alloy construction full-way split disc wedge pattern to BS 5154. Valves shall have inside screw gate, non-rising stem, high tensile bronze spindle and screwed bonnet. Valves shall have screwed female ends.
- l) Valves of 65mm bore and over shall be flanged cast-iron, fully sluice with inside screw solid wedge, non-rising stem and high tensile bronze spindle to BS 3464. Valves shall have bolted bonnets. Flanges of flanged valves shall be made to BS 4504 or other equivalent standards. However, valve for sprinkler system shall be of outside screw and yoke type in accordance with the requirement of SS CP52.
- m) At the pressure gauge, stainless steel bleed valve shall be provided (which act as a stop cock and enable bleed off small amount of water to read zero pressure).
- n) Valve Identification : All valves shall be identified by means of suitable tag or sign which shall clearly indicate the following :-
 - Section under control or served.
 - Valve number.
- o) Non-Return Valves : On the discharge end of each pump, a non-return valve shall be fitted. Valves shall be non-slamming hinged swing type to BS 5153, having cast iron body with bronze trim and be suitable for the working pressure of the system. Valves shall be suitable for installation in horizontal or vertical pipework. The valves shall be selected in relation to the velocity of the water in the pipes. In all cases, the valves are required to operate silently on reversal of water flow.

- p) Drain Valves/Cocks : Drain cocks of gland pattern shall be provided in such locations that all sections of piping systems can be drained, and shall be of 15mm size for pipes up to 50mm diameter, and 20mm size for larger pipes. Drain cocks shall be complete with stainless steel hose union.
- q) Air Release Valves : Automatic air eliminators, air bottles or air cocks of approved manufacture shall be provided at all high points where venting may be required.
- r) Strainers : Strainers shall be installed at the outlet of each water tank, water pump inlets, water gong inlets and other areas where necessary. Strainers shall be of "Y-type", flanged end, with stainless steel mesh of not less than 2mm x 2mm mesh. The bodies shall be of cast iron, with drain plug and end flange for draining and cleaning out purposes.
- s) Orifice Plates : Orifice plates shall be fitted as necessary in order to assist in hydraulically balancing the system and to provide the specified pressure/flow condition at the sprinkler. The orifice plates shall be approved type and installed in accordance with approved standards. Contractor shall submit calculation to the S.O. to determine the size of the orifice to achieve the desired pressure drop across the orifice plate.

11.16.15 Cleaning Procedure

- a) Every precaution shall be exercised to avoid introducing foreign matter such as welding beads and slag or dirt into piping system. Completed welds shall be hammered to loosen debris. All piping, valves and fittings shall be internally cleaned of oil, grease or dirt, prior to assembly into system, by use of wire brush and swab.
- b) Following fabrication and erection, all piping 150mm and smaller shall be cleaned by flushing with clean water and ran to waste until thoroughly free of all dirt, oil and cuttings, etc. Each size of pipe shall be flushed separately before being joined with larger size piping.
- c) Pipe of 20mm in diameter and larger shall be cleaned by pulling through a steel brush the entire length of each pipe size, followed by fibre brush or swab. Brushes and swabs shall be slightly larger than the inside diameter of the pipe being cleaned.
- d) All cleaning operations shall be continuous throughout the piping system, except at joints required for final jointing of various sections of cleaned piping. After cleaning and when the final joints have been made, the end of sections of piping shall be adequately and tightly sealed off to prevent any dirt, water or other foreign matter from entering through the ends of the pipe.
- e) All strainers shall be inspected and thoroughly cleaned. Before submitting piping systems for acceptance, Contractor shall provide temporary strainers where required for cleaning and flushing operation.
- f) The Contractor shall allow for the draining down of the entire system before commencing any alteration and modification Works.

11.17 Surface Treatment

11.17.1 Corrosion Protection

All materials and equipment supplied shall be suitable for being delivered stored and operated under tropical conditions of high temperature, high humidity, heavy rainfall and fungus-conducive environment.

11.17.2 Metal

- a) Iron and steel shall in general be painted or galvanised or metal-sprayed as appropriate. Indoor parts may alternatively have chromium or other suitable protective finish. When it is necessary to use dissimilar metals in contact, these shall be so selected that the potential difference between them in the electro-mechanical series shall not cause galvanic corrosion.
- b) If this is not possible, the contact surface of one or both of the metals shall be electro-plated or otherwise finished in such a manner that the potential difference is reduced within the required limits or, alternatively, the two metals shall be insulated from each other by a suitable insulating material or a coating of varnish compound.

11.17.3 Non-Metallic Materials

Non-metallic materials such as polycarbonate, glass-reinforced polyester, etc., which are exposed to weather, shall be resistant to deterioration by ultraviolet rays.

11.17.4 Bolts, Screws, Nuts

- a) Steel bolts, screws and nuts shall be sherardized as per BS 7371 : Part 8 (1998).
- b) Corrosion-resisting steel, copper-nickel alloy or bronze, shall also be used for bolts and nuts throughout the works, when they are subject to frequent adjustment or removal.
- c) Connection shall be such that potential differences do not cause galvanic corrosion.

11.17.5 Painting**11.17.5.1 Metal Items and Structures**

All surfaces to be painted shall be thoroughly cleaned of all dirt, dust, grease, oil and rust before the paint application.

11.17.5.2 Priming

The primer serves as a basic protection against corrosion and additionally to guarantee adherence between surface and the finish paint. Zinc-epoxy, zinc-chromate or red lead primers are suggested for this purpose.

11.17.5.3 Finishing

- a) Two finish coatings of minimum 0.05mm thickness shall be applied to painted surfaces. The proposed materials (epoxy resin base preferred), coat thickness, colours, etc. are subject to the Authority's approval.
- b) For items that are not painted, the zinc coating shall have minimum 500g/sq.m of coated surface.
- c) Any electrical boxes or other housing enclosures outdoors shall be of weather proof type.

12 APPENDICES

APPENDIX 2 TYPICAL CONTROL AND MONITORING POINT SCHEDULE FOR BUILDING MANAGEMENT SYSTEM

1. Air-conditioning and mechanical ventilation system

A. Intake Fans/ Exhaust Fans/ Smoke Purging Fans / Smoke Control Fans

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Local / Remote Status	√				
2	On/Off Status	√				
3	Trip/ Fault Alarm	√				
4	On Control		√			
5	Off Control		√			
6	Normal / Fire Mode Status	√				Only applicable to fans operating under fire mode
7	Emergency Stop Button Open/ Close	√				Only applicable to fans operating under fire mode

B. Sensors

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Temperature reading			√		Air-monitoring stations shall be provided at the covered bus parking area, driveway and boarding/ alighting bay areas to monitor the air quality and to activate the ventilation fans when air quality criteria is exceeded.
2	Temperature sensor malfunction reading	√				
3	CO reading			√		
4	CO sensor malfunction reading	√				One air monitoring station shall be provided to control each set of supply and exhaust ventilation zone within the covered bus parking area, driveway and boarding/ alighting bay areas.
5	NO _x / NO ₂ reading			√		
6	NO _x / NO ₂ sensor malfunction reading	√				

C. Smoke Curtain

Item	Input / Output Description (Per Curtain)	Type of Input / Output Points				Remark
		DI	DO	AI	AO	
1	Local / Remote Status	√				
2	Trip/ Fault Alarm	√				
3	On Status	√				
4	Off Status	√				
5	On Control		√			
6	Off Control		√			

D. Motorised Dampers / Motorised Fire Dampers

Item	Input / Output Description	Type of Input /Output Points				Remarks
		DI	DO	AI	AO	
1	Open Status	√				
2	Close Status	√				
3	Open Control		√			
4	Close Control		√			

E. Water-cooled Chillers

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Local Remote Status	√				
2	On/Off Status	√				
3	Trip/ Fault Alarm	√				
4	Motorized Valve Open Status	√				For all motorized valves.
5	Motorized Valve Close Status	√				For all motorized valves
6	Motorized Valve Open Control		√			For all motorized valves.
7	Motorized Valve Close Control		√			For all motorized valves.
8	On Control		√			
9	Off Control		√			
10	Flowrate reading for chilled water return			√		
11	Flowrate reading for condenser water supply			√		
12	Temperature reading for chilled water supply			√		
13	Temperature reading for chilled water return			√		
14	Temperature reading for condenser water supply			√		
15	Temperature reading for			√		

	condenser water return					
16	Chiller water temperature set point					Software point

F. Supplied/ Returned Chilled Water Header

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Differential Pressure			√		
2	Bypass Valve % Opening Feedback			√		
3	Chiller Water Header Supply Temperature			√		
4	Chiller Water Header Return Temperature			√		
5	Chiller Water Header Return Flow Rate			√		
6	Bypass Valve Control				√	

G. Supplied/ Returned Condenser Water Header

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Condenser Water Header Supply Temperature			√		
2	Condenser Water Header Return Temperature			√		
3	Condenser Water Header Return Flow Rate			√		

H. Water Tanks

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	

1	Tank High Level Alarm	√				
2	Tank Low Level Alarm	√				

I. Pumps

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Local / Remote Status	√				
2	On/Off Status	√				
3	Trip/ Fault Alarm	√				
4	On Control		√			
5	Off Control		√			

J. Cooling Towers

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	On/Off Status	√				
2	Trip Status	√				
3	Local / Remote Status	√				
4	Motorized Valve Open Status	√				For all motorized valves.
5	Motorized valve Close Status	√				For all motorized valves.
6	Motorized Valve Open Control		√			For all motorized valves
7	Motorized Valve Close Control		√			For all motorized valves.
8	Control On		√			
9	Control Off		√			
10	Water Basin High Alarm	√				
11	Water Basin Low Alarm	√				

K. Chilled Water Air Handling Unit (AHU)

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Local / Remote Status	√				
2	On/Off Status	√				
3	Trip/Fault Alarm	√				
4	AHU Smoke Probe Unit	√				
5	On Control		√			The AHU and modulating valve shall be interlocked such that when the AHU is not running, the valve shall be closed.
6	Off Control		√			
7	Supply Air Temperature			√		
8	Return Air Temperature			√		
9	Off-coil Temperature			√		
10	Space Temperature			√		Minimum three sensors for each AHU
11	Outdoor Temperature			√		
12	Dirty Filter Alarm			√		
13	Modulating Control Valve % Opening Feedback			√		
14	Chilled Water Supply Temperature			√		
15	Chilled Water Return Temperature			√		
1	Modulating control Valve Control				√	
17	Temperature Setpoint for AHU					Software point

L. Chilled Water Fan Coil Unit (FCU)

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Local / Remote Status	√				
2	On/Off Status	√				
3	Trip/Fault Alarm	√				
4	On Control		√			The FCU and control valve shall be interlocked such that when the FCU is not running, the valve shall be closed.
5	Off Control		√			
6	Control Valve Open/Close Status	√				Applicable for FCUs with cooling capacity less than 10 kW
7	Control Valve Open/Close Control		√			
8	Modulating Control Valve % Opening Feedback			√		Applicable for FCUs serving rooms housing critical/ electronics equipment or FCUs with cooling capacity more than 10 kW.
9	Modulating Control Valve Control				√	
10	Room Temperature			√		Applicable for rooms housing critical electronics equipment
11	Temperature Setpoint for FCU					Software point

M. Air-cooled split air-conditioning unit – Package Evaporator Unit (PEU)

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Local / Remote Status	√				
2	On/ Off Status	√				
3	Trip/Fault Alarm	√				
4	On Control		√			
5	Off Control		√			
6	Room Temperature			√		Applicable for rooms housing critical/ electronics equipment
7	Temperature Setpoint for FCU					Software point

N. Air-cooled split air-conditioning unit – Package Condensing Unit (PCU)

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Local / Remote Status	√				
2	On/ Off Status	√				
3	Trip/ Fault Alarm	√				
4	On Control		√			
5	Off Control		√			

O. Motor Control Center (MCC)/ Local Motor Control Panel (LMCP)/ Pump Control Panel

Item	Input / Output Description	Type of Input / Output points				Remarks
		DI	DO	AI	AO	
1	Power On/ Off Status	√				
2	Trip/ Fault Alarm	√				
3	KWHr			√		

4	Voltage			√		
5	Current			√		

P. Variable Speed Drive

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	VSD Speed Monitoring			√		
2	VSD Control On / Off				√	

Q. Chemical and Non-chemical treatment systems

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	DO	
1	On / Off Status	√				
2	Trip Status	√				
3	Local / Remote Status	√				
4	Control On		√			
5	Control Off		√			

2. Electrical Services

A. Main Switchboards

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Incoming Breaker Open Status	√				Per MSB
2	Incoming Breaker Close Status	√				Per MSB

3	Incoming Breaker Trip Status	√				Per MSB
4	Incoming Breaker Remote Close Control		√			Per MSB
5	Incoming Breaker Remote Open Control		√			Per MSB
6	Selector Switch Operation Mode Status	√				Per MSB
7	Power Consumption (kWhr)			√		Per MSB
8	110 VDC Auxiliary Control Source Failure	√				Per MSB
9	PLC Watchdog (Fault / Ok)	√				Per MSB
10	Outgoing Breaker Open Status	√				Per outgoing breaker
11	Outgoing Breaker Close Status	√				
12	Outgoing Breaker Trip Status	√				

B. Lighting

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Lighting On/Off Status	√				Per Lighting Zone
2	Outgoing MCB Trip Signal	√				Per Lighting Zone

C. Public Lighting Programmable Logic Control Panel

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Concourse Level 33% On Control		√			
2	Concourse Level 66% On Control		√			

3	Concourse Level 100% On Control		√			
4	Concourse Level 33% Off Control	√				
5	Concourse Level 66% Off Control	√				
6	Concourse Level 100% Off Control	√				

D. Generators

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Close	√				
2	Open	√				
3	Trip	√				
4	Remote Close		√			
5	Remote Open		√			

E Uninterruptible Power Supply (UPS)

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	UPS On Maintenance Bypass	√				
2	UPS on Battery	√				
3	Summary Fault	√				

3. Fire Protection System

A. Fire Pumps including sprinkler, jockey and hosereel pumps

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Local / Remote Status	√				
2	Run/Stop Status	√				
3	Trip/ Fault Alarm	√				
4	Control Valve Anti-tamper Switch alarm	√				Applicable for sprinkler system only
5	Sprinkler Alarm Valve Open / Close Status	√				Applicable for sprinkler system only

B. Pump Control Panels

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Power On/ Off Status	√				Per Control Panel
2	Trip/ Fault Alarm	√				

C. Fire Tanks including sprinkler and hosereel tanks

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Tank High Level Alarm	√				Per Tank
2	Tank Low Level Alarm	√				

D. Fire Main Alarm Panel (MAP)

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	MAP/ Repeater Panel Fault Summary Alarm	√				
2	MAP Fire Summary Alarm	√				
3	MAP Zone Isolate Summary Alarm	√				

E. Fire Sub Alarm Panels (SAPs)

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	SAP Fault Summary Alarm	√				Per SAP
2	SAP Fire Summary Alarm	√				

4. Plumbing & Sanitary System

A. Drainage Sump Pump

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Control Panel Power Supply Alarm Summary	√				Per Control Panel
2	Pump Run/Stop Status	√				Per Pump
3	Pump Trip Alarm	√				Per Pump
4	Pit Overflow Level Alarm	√				Per Sump Pit
5	Pit Low Level Alarm	√				Per Sump Pit

B. Sewage Ejector Tank & Pump.

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Control Panel Power Supply On/Off Alarm	√				Per Control Panel
2	Control Panel Power Supply Alarm Summary	√				Per System
3	Ejector Pump Run/Stop Status	√				Per Pump
4	Ejector Pump Trip Summary Alarm	√				Per System
5	Ejector Sump Pump Run/Stop Status	√				Per Pump
6	Ejector Sump Pump Trip Alarm	√				Per Pump
7	Ejector Tank Overflow Level Alarm	√				Per Ejector Tank
8	Ejector Tank Low Level Alarm	√				Per Ejector Tank
9	Pit Overflow Level Alarm	√				Per Sump Pit

C. Sewage Sump Pump

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Control Panel Power Supply Alarm Summary	√				Per Control Panel
2	Pump Run/Stop Status	√				Per Pump
3	Pump Trip Summary Alarm	√				Per System
4	Pit Overflow Level Alarm	√				Per Sump Pit
5	Pit Low Level Alarm	√				Per Sump Pit

D. Cold Water Booster Pump

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	

1	Control Panel Power Supply Alarm Summary	√				Per Control Panel
2	Pump Run/Stop Status	√				Per Pump
3	Pump Trip Summary Alarm	√				Per System
4	Tank Overflow Level Alarm	√				Per System
5	Tank Low Level Alarm	√				Per System

5. Lift & Escalator

A. Lift

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Summary Alarm	√				Per Lift
2	Summary Fault/Trip	√				
3	Maintenance Status	√				
4	Power On/Off Status	√				
5	Operation On/Off Status	√				

B. Escalator

Item	Input / Output Description	Type of Input / Output Points				Remarks
		DI	DO	AI	AO	
1	Stop Status	√				Per Escalator
2	Up / Forward Direction	√				
3	Down / Reverse Direction	√				
4	Trip/Fault Status	√				
5	Maintenance Status	√				
6	Power On/Off Status	√				
7	Remote Stop		√			

Notes:

1. Monitoring and control points are indicative and are subjected to acceptance by the Authority during detailed design.
2. Monitoring and control point schedules indicate are typical for equipment. Quantities of points are to be provided based on equipment schedule.
3. Alarm priority / level for DI and AI shall be proposed and developed in detailed design. These shall be subjected to acceptance by the Authority.

Architectural Checklist For Bus Interchange

PART 1. INFORMATION ON BUS INTERCHANGE

A. Address :

Bus Interchange Lot/Mk No: _____

Total Number of Bus Services : _____

Total Bus Frequency : _____ buses per peak hour

Submission Status : * Concept/Prelim/Detail
(*delete where applicable)

B. Location of bus interchange

Attach site plan showing location of existing or new bus interchange including:

- Classification of roads and its category.
- Catchment areas in the vicinity of the bus interchange (within 50 to 100m) to be indicated (hatched).

Specify catchment areas:

(✓) Tick the appropriate box(es)

a) Schools

☐

f) Neighbourhood Centre

☐

b) Offices

☐

g) Market

☐

c) Factories

☐

h) MRT Station

☐

d) Shopping Centre

☐

i) LRT Station

☐

e) Town Centre

☐

j) Others (specify)

☐

PART 2. STANDARD REQUIREMENTS FOR BUS INTERCHANGE

(✓)Tick the appropriate box for all items

Standard Requirements	Complied	Not Complied	Remarks
2.1 General			
2.1.1 Overview			
(a) References shall be made to Drawings L/CFADC/AR/BI/0001-0013 when using this document.	<input type="checkbox"/>	<input type="checkbox"/>	
(b) This document shall apply to all temporary and permanent bus interchanges and bus terminals (collectively named as bus interchange), unless otherwise exempted, with the written approval from LTA.	<input type="checkbox"/>	<input type="checkbox"/>	
(c) An integrated bus interchange is one that is built as an integral part of a larger development.	<input type="checkbox"/>	<input type="checkbox"/>	
(d) A standalone bus interchange is one that is not enclosed, with natural ventilation for the concourse and bus park area.	<input type="checkbox"/>	<input type="checkbox"/>	

Standard Requirements		Complied	Not Complied	Remarks
2.1.2	Statutory Requirements and LTA Requirements/ Guidelines			
(a)	Internal and external road elements, including but not limited to, traffic signs, road markings, road humps, thermoplastic markings, signalisation, pedestrian crossings, vehicular impact guardrails, impact bollards, etc shall comply with the latest LTA Standard Details of Road Elements (SDRE) requirements.	<input type="checkbox"/>	<input type="checkbox"/>	
(b)	Comprehensive Public Transit Signage System plan, within the bus interchange and its vicinity including the new development, shall be developed, designed and provided in accordance with LTA Signage Design Guideline Manual, Tender Conditions and Reference Manual. The provision, layout, location and detailed design of the signage shall be carried out in consultation with LTA.	<input type="checkbox"/>	<input type="checkbox"/>	
(c)	For bus interchange which is in the vicinity of residential housing, noise mitigation measures shall be provided, unless otherwise stated.	<input type="checkbox"/>	<input type="checkbox"/>	
(d)	In addition to NParks' green buffer requirement, additional landscaping in and around the bus interchange shall be provided, unless otherwise stated.	<input type="checkbox"/>	<input type="checkbox"/>	
2.1.3	Studies and Submissions			
(a)	The following studies and reviews shall be carried out and submitted by a specialist/ traffic consultant/ qualified persons to the Authority for approval prior to the finalisation of the bus interchange design and layout:	<input type="checkbox"/>	<input type="checkbox"/>	
i.	Traffic Impact Assessment (TIA), unless otherwise specified by the Authority;	<input type="checkbox"/>	<input type="checkbox"/>	
ii.	Traffic Scheme/ Plan, mandatory for all bus interchanges;	<input type="checkbox"/>	<input type="checkbox"/>	
iii.	Security Consultancy Study, for bus interchange classified as National Critical Infrastructure or Key Installation if required by the Authority;	<input type="checkbox"/>	<input type="checkbox"/>	
iv.	Acoustic Study, mandatory for integrated bus interchange;	<input type="checkbox"/>	<input type="checkbox"/>	
v.	Bus Interchange Simulation Study, mandatory for all bus interchanges;	<input type="checkbox"/>	<input type="checkbox"/>	
vi.	Project Safety Review PSR (Roads) by a qualified independent safety reviewer, mandatory for all bus interchanges;	<input type="checkbox"/>	<input type="checkbox"/>	
vii.	All mechanical and electrical system studies as required under ADC Section 4.2. e.g. Lighting Study, Computational Fluid Dynamics (CFD) Study, Environmental Impact Assessment (EIA) study, and	<input type="checkbox"/>	<input type="checkbox"/>	
viii.	Pedestrian Simulation Study, as required under ADC Section 2.	<input type="checkbox"/>	<input type="checkbox"/>	
(b)	The recommendations of the above studies shall be incorporated in the bus interchange design and mitigation provisions shall be catered for prior to the construction of the bus interchange.	<input type="checkbox"/>	<input type="checkbox"/>	
2.1.4	Design Principles and Considerations			
(a)	All design principles and requirements outlined in all other relevant sections of the ADC shall be complied. Specifically;	<input type="checkbox"/>	<input type="checkbox"/>	

Standard Requirements		Complied	Not Complied	Remarks
i.	Interfacing development requirements in ADC Section 2 – Chapter 10,	<input type="checkbox"/>	<input type="checkbox"/>	
ii.	Security requirements in ADC Section 2 – Chapter 14	<input type="checkbox"/>	<input type="checkbox"/>	
iii.	Ease of maintenance requirements in ADC Section 2 – Chapter 16,	<input type="checkbox"/>	<input type="checkbox"/>	
iv.	Mechanical and electrical system requirements in ADC Section 4.2	<input type="checkbox"/>	<input type="checkbox"/>	
v.	Commuter facility requirements across ADC sections 4.3 to 4.9.	<input type="checkbox"/>	<input type="checkbox"/>	
(b) The bus interchange shall be designed with the following principles in mind:		<input type="checkbox"/>	<input type="checkbox"/>	
i.	Ease of use by commuters, i.e. minimise transfer walking distance, ensure comfortable , safe and secure environment, ease of way finding, etc; and	<input type="checkbox"/>	<input type="checkbox"/>	
ii.	Cost and operational efficiency of bus interchange, i.e. ensure ease of operation and maintenance, reduce recurrent costs, provide safe and efficient layout, promote staff welfare, etc.	<input type="checkbox"/>	<input type="checkbox"/>	
iii.	Natural lighting shall be brought into public spaces where possible	<input type="checkbox"/>	<input type="checkbox"/>	
2.2 Bus Park Area				
2.2.1 Overview				
(a)	The bus park area shall include all the alighting berths, boarding berths, parking lots, circulation driveway, ingresses, egresses, etc.	<input type="checkbox"/>	<input type="checkbox"/>	
(b)	The bus park area shall be designed to be naturally ventilated unless otherwise agreed by the Authority.	<input type="checkbox"/>	<input type="checkbox"/>	
(c)	The bus park area shall be designed such that buses need not reverse at any time. In the event that there are serious space constraints, which the designer shall demonstrate that all options are exhausted, only 12m standard buses are allowed to reverse for the design of the driveway and bus parking area. For such cases, sufficient and satisfactory mitigating safety measures (e.g. convex mirrors, reverse sensors) shall be provided. 18m articulated buses shall not reverse within bus interchange for safety reasons.	<input type="checkbox"/>	<input type="checkbox"/>	
(d)	The design shall be such that passenger loaded buses need not travel in the driveway where buses are reversing. If unavoidable and upon approval by the Authority, a separate 3.7m lane shall be provided next to the driveway where buses are reversing.	<input type="checkbox"/>	<input type="checkbox"/>	
(e)	The bus park area shall be designed with minimal structural columns, unnecessary structures, kerbs or other building elements so as to minimise visual obstruction to the bus drivers and improve the efficiency and safety of bus circulation.	<input type="checkbox"/>	<input type="checkbox"/>	
(f)	There shall be no pedestrian routes within the bus parking and bus circulation areas of the bus interchange.	<input type="checkbox"/>	<input type="checkbox"/>	
(g)	A minimum clear height of 5.4m, measured from the road level to the underside of all structures or services (e.g. M&E), is required.	<input type="checkbox"/>	<input type="checkbox"/>	

Standard Requirements	Complied	Not Complied	Remarks
(h) The lateral clearance between the outer edge of the road kerb and any element shall be minimum 0.6m. Bus park area shall be designed with additional clearance taking into considerations the low bus overhangs for wheelchair accessible buses.	<input type="checkbox"/>	<input type="checkbox"/>	
(i) Bus interchange floor shall be designed and treated to minimise vibration impact to the adjoining occupancies caused by the buses travelling at the speed of 30km/h. The assessment of building vibration with respect to human response in adjoining occupancies shall be evaluated in accordance with BS 6472-1: 2008. The vibration dose value predicted shall meet the range with low probability of adverse comments in accordance with Table 1 in BS 6472 for the respective occupied space in the building.	<input type="checkbox"/>	<input type="checkbox"/>	
(j) The structural elements within the bus interchange shall be designed for vehicular impact load and installed with protection bumper. Otherwise, vehicle impact guardrails or bollards shall be installed.	<input type="checkbox"/>	<input type="checkbox"/>	
(k) For proper water drainage, the bus driveway shall be designed with proper run-off and drainage at the perimeter. Catch basin drainage for water catchment shall be provided on the driveway where all boarding and alighting berths are positioned [for details refer to SDRE].	<input type="checkbox"/>	<input type="checkbox"/>	
(l) The platform level of the bus park area shall be higher than the surrounding roads.	<input type="checkbox"/>	<input type="checkbox"/>	
(m) Traffic schemes/ plans shall be provided covering the entire bus park area and peripheral access junctions.	<input type="checkbox"/>	<input type="checkbox"/>	
2.2.2 Bus Interchange Simulation Study and Bus Trials			
(a) A Bus Interchange Simulation Study (e.g. swept path/ auto turn analysis) shall be carried out covering the entire bus park area and submitted by an independent specialist/ traffic consultant to the Authority for approval prior to the finalisation of the bus interchange design and layout.	<input type="checkbox"/>	<input type="checkbox"/>	
(b) The scenarios of this study shall include the worst case scenario within the bus interchange, with fully parked buses, fully occupied berths, more than 1 bus waiting to exit, bus overtaking, etc. Parameters of the study, methodology, analysis of the full cycle of the bus movement from the bus entrance into the bus interchange to its exit, and softcopies shall be shared with the Authority and the operators.	<input type="checkbox"/>	<input type="checkbox"/>	
(c) This study shall verify and ensure that the bus circulation, parking, berthing, etc within the bus interchange are safe and efficient for operation.	<input type="checkbox"/>	<input type="checkbox"/>	
(d) This study shall verify and ensure that all berths can allow berthing of wheelchair accessible buses with easy accessibility for passenger-in-wheelchair. The study shall demonstrate that the bus can align parallel and as close to the berth kerb as possible.	<input type="checkbox"/>	<input type="checkbox"/>	
(e) In addition to this study, bus trials on site shall be carried out so as to satisfy the Authority and the operators that the above requirements have been met.	<input type="checkbox"/>	<input type="checkbox"/>	

Standard Requirements				Complied	Not Complied	Remarks
2.2.3 Bus Ingress & Egress						
(a) The number of bus ingresses/ egresses, their nature (separate or combined) and junction arrangement (i.e. full movement signalised junction or limited movement) shall be provided as advised by the Authority. The bus ingresses/ egresses shall have priority over other development accesses, lay-bys, etc.				<input type="checkbox"/>	<input type="checkbox"/>	
(b) Chain gates or barriers shall be provided at the ingresses and egresses. The gates or barriers shall not impede the bus operations and pedestrian flow. To prevent jaywalking, perimeter fencing shall be provided along the perimeter of the bus park.				<input type="checkbox"/>	<input type="checkbox"/>	
(c) Where the pedestrian needs to traverse the ingresses or egresses, signalised pedestrian crossing, overhead or underground pass shall be provided.				<input type="checkbox"/>	<input type="checkbox"/>	
(d) There shall be no obstruction to sight at all the ingresses and egresses. Bus Drivers shall have a clear view of the main road traffic prior to exiting from the bus interchange driveway onto the main road. Minimum clear sight distance shall be provided in accordance with the LTA Civil Design Criteria.				<input type="checkbox"/>	<input type="checkbox"/>	
(e) Double-sided road signs "Buses To Look Out For pedestrians" shall be provided at both sides of all the ingresses and egresses.				<input type="checkbox"/>	<input type="checkbox"/>	
(f) "No Entry except Authorised Vehicles" signs shall be provided at both sides of all the ingresses and egresses.				<input type="checkbox"/>	<input type="checkbox"/>	
(g) Chevron markings on the driveway and road shall be provided at the ingresses and egresses to guide and prevent buses from coming too close to the kerbs.				<input type="checkbox"/>	<input type="checkbox"/>	
(h) Double zigzag lines outside the ingresses and egresses shall be provided.				<input type="checkbox"/>	<input type="checkbox"/>	
(i) The width of the ingresses and egresses shall be minimum 8m for single-direction and minimum 10m for dual-direction, subject to the Bus Interchange Simulation Study.				<input type="checkbox"/>	<input type="checkbox"/>	
2.2.4 Bus Parking Lots						
(a) The number of bus parking lots provision shall be 3 parking lots per bus service.				<input type="checkbox"/>	<input type="checkbox"/>	
(b) The parking lot dimensions shall be as follow:						
Type of Parking Lot	Overall Width (m)	Overall Length (m)	Equidistance of parallel lots	<input type="checkbox"/>	<input type="checkbox"/>	
12m Standard	3.5	12.7	4m apart			
18m Articulated	3.5	18.2	6m apart			
(c) All bus parking lots shall fully accommodate standard 12m bus. Numbers of lots accommodating 18m articulated buses to be confirmed by the Authority.				<input type="checkbox"/>	<input type="checkbox"/>	
(d) Bus parking lots shall be demarcated with 100mm wide thermoplastic paint marking. Lots markings shall be yellow or other colours as prescribed by the Authority. For the paint marking, refer to Drawing ref. L/CFADC/AR/BI/0003.				<input type="checkbox"/>	<input type="checkbox"/>	

Standard Requirements	Complied	Not Complied	Remarks										
(e) Bus park wheel stoppers and humps shall be provided for all bus parking lots. They shall be cast in-situ together with the bus park area with proper reinforcement bars/ bolts to the ground. For details of bus park wheel stoppers, refer to Drawing ref. L/CFADC/AR/BI/0003.	<input type="checkbox"/>	<input type="checkbox"/>											
2.2.5 Driveway													
(a) The minimum clear width of the driveway shall be as follows:													
<table border="1"> <thead> <tr> <th>Type of Driveway</th> <th>Minimum Clear Width (m)</th> </tr> </thead> <tbody> <tr> <td>Saw-tooth Bus Park with driveway on 1 side/ One-directional</td> <td>12</td> </tr> <tr> <td>Saw-tooth Bus Park with driveway on both sides/ Two directional</td> <td>14</td> </tr> <tr> <td>End-on Bus Park with driveway on 1 side / One directional</td> <td>18</td> </tr> <tr> <td>End-on Bus Park with driveway on both sides / Two directional</td> <td>21</td> </tr> </tbody> </table>	Type of Driveway	Minimum Clear Width (m)	Saw-tooth Bus Park with driveway on 1 side/ One-directional	12	Saw-tooth Bus Park with driveway on both sides/ Two directional	14	End-on Bus Park with driveway on 1 side / One directional	18	End-on Bus Park with driveway on both sides / Two directional	21	<input type="checkbox"/>	<input type="checkbox"/>	
Type of Driveway	Minimum Clear Width (m)												
Saw-tooth Bus Park with driveway on 1 side/ One-directional	12												
Saw-tooth Bus Park with driveway on both sides/ Two directional	14												
End-on Bus Park with driveway on 1 side / One directional	18												
End-on Bus Park with driveway on both sides / Two directional	21												
(b) Kerb height for driveway and berths shall be 150 mm with black/ white strip painting.	<input type="checkbox"/>	<input type="checkbox"/>											
(c) Kerb height at front of end-on-berth parking lots shall be 120mm with black/ white strip painting.	<input type="checkbox"/>	<input type="checkbox"/>											
(d) Driveway ramp gradient shall not be steeper than 1:20.	<input type="checkbox"/>	<input type="checkbox"/>											
(e) In the event that an up-ramp and a down-ramp are needed, the design shall cater and ensure that the point of apex of the ramps clears the bus undercarriage, and front and rear overhangs of the bus. Otherwise, a flat area shall be provided for at least an 18m articulated bus.	<input type="checkbox"/>	<input type="checkbox"/>											
(f) Proper footpaths and pedestrian crossings shall be provided for bus drivers/ operations and maintenance staff.	<input type="checkbox"/>	<input type="checkbox"/>											
(g) Adequate “No Walking Within Bus Park” signs shall be provided (refer to LTA Signage Reference Manual). The signs and location shall be proposed for the Authority’s approval.	<input type="checkbox"/>	<input type="checkbox"/>											
2.2.6 Boarding/ Alighting Berths													
(a) The bus interchange shall be designed to cater for the expected number of bus services as prescribed by the Authority.	<input type="checkbox"/>	<input type="checkbox"/>											
(b) For saw-tooth design, the arrangement of the berths shall be in a clockwise manner, starting with alighting berths followed by boarding berths.	<input type="checkbox"/>	<input type="checkbox"/>											
(c) Large, visible and reflective berth number plates outside the concourse shall be provided. The numbering system shall be in clockwise manner, starting with A1 for alighting berth one, B1 for boarding berth one and so on so forth.	<input type="checkbox"/>	<input type="checkbox"/>											
(d) The type of berths and number of bus services shall be as follow:													
<table border="1"> <tbody> <tr> <td>Saw-tooth Boarding</td> <td>3 bus services per berth</td> </tr> <tr> <td>End-on Boarding and Alighting</td> <td>3 berths per service</td> </tr> <tr> <td>Straight Alighting</td> <td>6 bus services per berth</td> </tr> </tbody> </table>	Saw-tooth Boarding	3 bus services per berth	End-on Boarding and Alighting	3 berths per service	Straight Alighting	6 bus services per berth	<input type="checkbox"/>	<input type="checkbox"/>					
Saw-tooth Boarding	3 bus services per berth												
End-on Boarding and Alighting	3 berths per service												
Straight Alighting	6 bus services per berth												

Standard Requirements	Complied	Not Complied	Remarks
(e) All boarding and alighting berths shall fully accommodate standard 12m bus. Number and allocation of berths accommodating 18m articulated buses to be confirmed by the Authority.	<input type="checkbox"/>	<input type="checkbox"/>	
(f) For saw-tooth boarding berths, the angle of approach shall be 10 degrees to the berths. The length of saw-tooth boarding berths shall be 20m for 12m standard buses. For details, refer to Drawing ref. L/CFADC/AR/BI/0012.	<input type="checkbox"/>	<input type="checkbox"/>	
(g) The first alighting berth after the ingress and the last saw-tooth boarding berth before the egress shall be at least of a straight line distance of 12m.	<input type="checkbox"/>	<input type="checkbox"/>	
(h) At the L-shape bend, the berth after the bend shall have a clear distance of 15m from the last berth (or less depending on Bus Interchange Simulation Study) before the bend.	<input type="checkbox"/>	<input type="checkbox"/>	
(i) For end-on berths, the boarding and alighting 'tongue' shall be minimum clear width 1.5m, measured from the road kerb to the outer edge of any railing or obstruction, and in compliance to the requirements of the Code on Accessibility in Buildings. Safety guide stainless steel railings shall be provided along the 'tongue'. Please refer to Drawing L/CFADC/AR/BI/0001.	<input type="checkbox"/>	<input type="checkbox"/>	
2.2.7 Safety Provisions			
(a) Retro reflective sheet shall be provided on the surface of walls, columns, bollards or any other vertical elements.	<input type="checkbox"/>	<input type="checkbox"/>	
(b) Large (not less than 1m diameter/ length) convex mirrors, cylindrical convex mirrors, reverse sensor with warning lights, whichever appropriate, shall be provided, where there are blind spots and visual obstruction.	<input type="checkbox"/>	<input type="checkbox"/>	
(c) There shall be a clear segregation between the pedestrian and bus circulation.	<input type="checkbox"/>	<input type="checkbox"/>	
(d) Vehicle impact guardrail shall be provided for hose reels, hydrants, lamp posts, M&E ducting etc.	<input type="checkbox"/>	<input type="checkbox"/>	
(e) Depending on the types of bus interchange, safety bollards or security bollards shall be installed along the edge of concourse next to the bus park area.	<input type="checkbox"/>	<input type="checkbox"/>	
2.2.8 Design and Finishes			
(a) The bus park shall be designed in accordance to latest LTA SDRE requirements and LTA Materials and Workmanship (M&W) Specifications for Roadworks Chapter 10.	<input type="checkbox"/>	<input type="checkbox"/>	
(b) For temporary bus interchange (less than 5 years use), the bus park area, including the access junctions, shall at least be made of rigid pavement. Refer to Standard Details of Road Elements (SDRE) for details.	<input type="checkbox"/>	<input type="checkbox"/>	
(c) For permanent bus interchange, the bus park area, including the access junctions, shall be made of semi-rigid pavement system. For details refer to LTA's Civil Material and Workmanship Specification or Project Specifications.	<input type="checkbox"/>	<input type="checkbox"/>	
(d) The design and colour of the bus park shall be designed with contrast such that the traffic markings are visible.	<input type="checkbox"/>	<input type="checkbox"/>	

Standard Requirements				Complied	Not Complied	Remarks
2.3 Concourse Area						
2.3.1 Overview						
(a) The concourse area shall include all the alighting, boarding berths, offices, other facilities, etc as stated in this document.				<input type="checkbox"/>	<input type="checkbox"/>	
(b) A minimum clear width, free from all encumbrances (including queue rails), shall be provided along the concourse based on the following:						
No. of Bus Services (n)	n < 10	10 ≤ n ≤ 20	>20	<input type="checkbox"/>	<input type="checkbox"/>	
Minimum clear width (m)	6	8	10			
(c) The concourse shall be designed with minimal structural columns within the concourse area, entrances/ exits and doors.				<input type="checkbox"/>	<input type="checkbox"/>	
(d) The location and layout of the concourse shall be planned and designed such that the transfer between MRT, bus interchange and bus stops shall be direct and shortest. In addition, the connectivity between these transport nodes, development and commuter facilities (e.g. taxi stand, pick-up/ drop-off bays) shall be sheltered.				<input type="checkbox"/>	<input type="checkbox"/>	
(e) There shall be minimum 3m clear height to the underside of the ceiling.				<input type="checkbox"/>	<input type="checkbox"/>	
2.3.2 Commuter Accessibility						
(a) The number and width of pedestrian entrances/ exits and sheltered linkways from the concourse to nearby MRT station, bus stops, commuter facilities and developments prescribed by the Authority shall be a minimum and shall be increased if needed as determined by any Pedestrian Simulation.				<input type="checkbox"/>	<input type="checkbox"/>	
2.3.3 Air-conditioned Bus Interchange						
(a) The concourse shall be air-conditioned.				<input type="checkbox"/>	<input type="checkbox"/>	
(b) Where escalators are linked to the concourse, sufficient holding area, with a minimum of 6m distance from the escalator landing comb plates, shall be required. Staircase next to the escalators shall be provided, unless otherwise exempted by the Authority.				<input type="checkbox"/>	<input type="checkbox"/>	
2.3.3.1 Walls, Doors and Shutters						
(a) The segregation wall between the concourse and the bus park area shall be 1m height topped with laminated glass panels to the ceiling and then fully enclosed above the ceiling.				<input type="checkbox"/>	<input type="checkbox"/>	
(b) The segregation wall between the concourse and other development shall be a physically opaque wall, unless prior approval is obtained from the Authority.				<input type="checkbox"/>	<input type="checkbox"/>	
(c) All accesses from the Bus Interchange into any development or vice versa, shall be provided with security shutters.				<input type="checkbox"/>	<input type="checkbox"/>	

Standard Requirements	Complied	Not Complied	Remarks
(d) All entrances leading to outside road (excluding development), boarding and alighting berths shall be equipped with automated screen doors (ASD) with air curtains. These doors shall be heavy duty, tempered laminated glass and equipped with auto lock mechanism when they are switched off after operational hours. The ASD shall be designed to be switched off locally at individual screen doors and alternative remote access from the Passenger Service Office 1.	<input type="checkbox"/>	<input type="checkbox"/>	
(e) There shall be two sliding ASD for each boarding berth. Motion detector sensors on the interior side of the concourse and loop detector sensors on the berth driveways shall be provided to activate the ASD when a bus arrives. For alighting berth ASD, motion detector sensors shall be provided on the exterior side of the concourse area. For end-on berths, motion detector sensors shall be provided on both sides of the ASD.	<input type="checkbox"/>	<input type="checkbox"/>	
(f) Hands-off signs shall be provided at the side of each ASD. Refer to the LTA Signage Reference Manual for the sign details.	<input type="checkbox"/>	<input type="checkbox"/>	
(g) In addition to ASD, manual glass swing doors to the driveway shall be provided for every two berths. These doors shall be made of heavy duty tempered laminated glass.	<input type="checkbox"/>	<input type="checkbox"/>	
(h) All doors shall also be manually lockable.	<input type="checkbox"/>	<input type="checkbox"/>	
(i) Shutter bulk heads and ASD guide rails at the boarding and alighting berths shall be located within the bus park area or enclosed within the ceiling.	<input type="checkbox"/>	<input type="checkbox"/>	
2.3.3.2 Finishes			
(a) For walls, cladding finishes shall be provided. For floor, darker shades of tiles shall be provided. Slip resistance shall be in accordance to Section 2 of the ADC - Chapter 3	<input type="checkbox"/>	<input type="checkbox"/>	
2.3.4 Non air-conditioned Bus Interchange			
(a) The concourse of a non air-conditioned bus interchange shall be designed to be naturally ventilated. In addition, there shall be provision of industrial type oscillating fans at the concourse area.	<input type="checkbox"/>	<input type="checkbox"/>	
2.3.4.1 Roof			
(a) The design of the roof shall cover the entire concourse. In addition, the design of the roof shall cover the boarding and alighting berths driveway area, such that the entire bus, including double-decked bus and 18m articulated bus, is fully sheltered from the rain.	<input type="checkbox"/>	<input type="checkbox"/>	
(b) With the high roof, the design of the roof overhang, louvre/ screen shall ensure no rain pelting into the concourse.	<input type="checkbox"/>	<input type="checkbox"/>	
2.3.4.2 Finishes			
(a) For walls, it shall be weatherproof external grade anti fungal paint. For floor, it shall be granolithic.	<input type="checkbox"/>	<input type="checkbox"/>	
2.3.5 Queue Rails and Boarding/ Alighting Berths			
(a) Queue rails shall be provided at each boarding berth. Please refer to Drawing L/CFADC/AR/BI/0012 for details of the queue rails.	<input type="checkbox"/>	<input type="checkbox"/>	

Standard Requirements	Complied	Not Complied	Remarks								
(b) The minimum clear width for all queuing areas shall be 700mm and shall be measured between the outer edge of any element including queue rails, signage posts and bum rests.	<input type="checkbox"/>	<input type="checkbox"/>									
(c) The queue rails with bum-rests shall be stainless steel grade 304, hairline finish.	<input type="checkbox"/>	<input type="checkbox"/>									
(d) For all queue rails, overhead stainless steel frame with signage plates for berth number and bus service numbers shall be provided. The berth numbering system shall be in clockwise manner, starting with A1 for alighting berth one, B1 for boarding berth one and so on so forth.	<input type="checkbox"/>	<input type="checkbox"/>									
(e) At the side of all queue rails, signage plates for bus service numbers shall be provided.	<input type="checkbox"/>	<input type="checkbox"/>									
(f) The design of queue rails shall cater for sufficient waiting space for passengers-in-wheelchair which shall be demarcated on the ground with blue-coloured tiles. Pictogram signage shall be erected.	<input type="checkbox"/>	<input type="checkbox"/>									
(g) 600mm wide yellow tactile tiles shall be set at 0.6m away from driveway kerb perpendicular to commuters' flow. Please refer to Drawing ref. L/CFADC/AR/BI/0012.	<input type="checkbox"/>	<input type="checkbox"/>									
2.3.6 Seating Benches											
(a) One set of 4-seater benches with armrests shall be provided per boarding berth, with a minimum of six benches.	<input type="checkbox"/>	<input type="checkbox"/>									
(b) The benches shall be stainless steel grade 304, hairline finish and bolted to the ground.	<input type="checkbox"/>	<input type="checkbox"/>									
(c) The location and type/ design of the benches shall be proposed for the Authority's approval.	<input type="checkbox"/>	<input type="checkbox"/>									
2.3.7 Information Panel Boards											
(a) Information panel board with locks shall be provided. Refer to the LTA Signage Reference Manual.	<input type="checkbox"/>	<input type="checkbox"/>									
(b) The number of board sets shall be provided based on the following:	<input type="checkbox"/>	<input type="checkbox"/>									
<table border="1"> <tr> <th>No. of Bus Services (n)</th><th>n < 10</th><th>10 ≤ n ≤ 20</th><th>>20</th></tr> <tr> <td>Number of Board Set</td><td>2</td><td>3</td><td>4</td></tr> </table>	No. of Bus Services (n)	n < 10	10 ≤ n ≤ 20	>20	Number of Board Set	2	3	4	<input type="checkbox"/>	<input type="checkbox"/>	
No. of Bus Services (n)	n < 10	10 ≤ n ≤ 20	>20								
Number of Board Set	2	3	4								
(c) Each set shall have 4 glass panels, and may be single or double sided, depending on its location in the concourse, to be confirmed with the Authority.	<input type="checkbox"/>	<input type="checkbox"/>									
(d) The frame of the board shall be aluminium and bolted on ground or wall mounted.	<input type="checkbox"/>	<input type="checkbox"/>									
(e) The location of the boards shall be on one side of the concourse and not impede commuter flow. The location and type/ design of the board set shall be proposed for the Authority's approval.	<input type="checkbox"/>	<input type="checkbox"/>									
2.4 Offices and Other Facilities											
2.4.1 Overview											
(a) The offices and all facilities stated here shall be included in the concourse, unless otherwise stated.	<input type="checkbox"/>	<input type="checkbox"/>									
(b) All other M&E rooms and facilities needed for the functioning of the bus interchange (e.g. AHU, chiller plant, switch room, MDF, generator rooms) shall be in the concourse area.	<input type="checkbox"/>	<input type="checkbox"/>									

Standard Requirements				Complied	Not Complied	Remarks
(c) Signage for all offices and other facilities shall be provided.				<input type="checkbox"/>	<input type="checkbox"/>	
(d) The Passenger Service Office 1, Administration Office, Manager Room and Server Room, shall be designed to be contiguous. The Server Room shall be adjacent to Passenger Service Office 1. These, together with the Passenger Service Office 2, Ticket Office and Add Value Machine Room, which are adjacent to each other, shall be centrally located in the concourse.				<input type="checkbox"/>	<input type="checkbox"/>	
(e) All doors and windows shall be lockable.				<input type="checkbox"/>	<input type="checkbox"/>	
(f) The interior finish of all toilets, kitchens and canteen shall as a minimum be; tiled floor & walls and moisture resistant demountable suspended ceiling unless otherwise stated. Slip resistance shall be in accordance to SS 485..				<input type="checkbox"/>	<input type="checkbox"/>	
(g) The interior finish of all offices and other facilities below shall as a minimum be; tiled floor, plastered and painted wall and demountable suspended ceiling unless otherwise stated.				<input type="checkbox"/>	<input type="checkbox"/>	
(h) Electrical substation and any other M&E rooms not listed shall as a minimum be; Reinforced Concrete floor slab with screed and hardener, plastered and painted wall and ceiling.				<input type="checkbox"/>	<input type="checkbox"/>	
(i) Type and specifications of all materials including type and application of skirting shall be subject to confirmation and approval by the Authority.				<input type="checkbox"/>	<input type="checkbox"/>	
2.4.2 Minimum Size of Offices and Other Facilities						
No. of Bus Services (n)	n < 10	$10 \leq n \leq 20$	>20	<input type="checkbox"/>	<input type="checkbox"/>	
Passenger Service Office 1 (sqm)	12 (Frontage of 1 glass panels of width 2.2 m)	14 (Frontage of 2 glass panels of width 1.4m each)	18 (Frontage of 3 glass panels of width 1.4m each)	<input type="checkbox"/>	<input type="checkbox"/>	
Passenger Service Office 2 (sqm)	12 (Frontage of 1 glass panel of width 2.2m)			<input type="checkbox"/>	<input type="checkbox"/>	
Administrative Office (sqm)	20	28	36	<input type="checkbox"/>	<input type="checkbox"/>	
Manager Room, adjacent to Administrative Office (sqm)	8			<input type="checkbox"/>	<input type="checkbox"/>	
Staff Lounge cum Briefing Room (sqm)	55	75	100	<input type="checkbox"/>	<input type="checkbox"/>	
Staff Toilets, adjacent to Staff Lounge	Male	Cubicle	1 standard and 1 ambulant	<input type="checkbox"/>	<input type="checkbox"/>	
		Wash Basin	2			
		Urinal	2			
	Female	Cubicle	1 standard and 1 ambulant			
		Wash Basin	2			

Standard Requirements			Complied	Not Complied	Remarks
Server Room, adjacent to Passenger Service Office 1 (sqm)	7.5		<input type="checkbox"/>	<input type="checkbox"/>	
Ticket Office (sqm)	9 (Frontage of 1 glass panel of width 2.2m)	12 (Frontage of 2 glass panels of width 1.4m each)	<input type="checkbox"/>	<input type="checkbox"/>	
Add Value Machine (AVM) room (sqm)	1 AVM – 5sqm (2m wide frontage) 2 AVMs – 10sqm (4m wide frontage)		<input type="checkbox"/>	<input type="checkbox"/>	
Commercial Space, excluding circulation (sqm)	20% of concourse area, capped at 400		<input type="checkbox"/>	<input type="checkbox"/>	
ATM/ Public Phone/ Vending Machine Spaces (sqm)	7.5sqm (5nos. of 1.5sqm area)		<input type="checkbox"/>	<input type="checkbox"/>	
Canteen (sqm)	55 (Inclusive of 4.8sqm servery)	65 (Inclusive of 9.6sqm servery)	<input type="checkbox"/>	<input type="checkbox"/>	
Kitchen, adjacent to Canteen (sqm)	15	30	<input type="checkbox"/>	<input type="checkbox"/>	
Rodent-Free Storeroom, adjacent to Kitchen (sqm)	4.8		<input type="checkbox"/>	<input type="checkbox"/>	
Technician's Room (sqm)	6		<input type="checkbox"/>	<input type="checkbox"/>	
Store Room (sqm)	6		<input type="checkbox"/>	<input type="checkbox"/>	
Cleaner's Room, minimum door width 1.2m (sqm)	10		<input type="checkbox"/>	<input type="checkbox"/>	
First Aid Room cum Nursing Room (sqm)	7.5		<input type="checkbox"/>	<input type="checkbox"/>	
Special Purpose Room (sqm)	9		<input type="checkbox"/>	<input type="checkbox"/>	
Public Toilets (including handicap toilets)	Male	To follow NEA requirements + 1 extra set of cubicle, urinal and wash basin	<input type="checkbox"/>	<input type="checkbox"/>	
	Female	To follow NEA requirements			
2.4.3 Passenger Service Offices					
(a) The two Passenger Service Offices 1 (For Primary Bus Operator) and 2 (For Secondary Bus Operator) shall be independent rooms with their own dedicated access. Doors shall be opened to the concourse area.			<input type="checkbox"/>	<input type="checkbox"/>	
(b) Laminated glass panel and half wall with or without customised openings (for Bus Captain tapping machine) and with service counter top shall be provided, with the provision and dimension of the customised openings to be confirmed by the bus operators.			<input type="checkbox"/>	<input type="checkbox"/>	
(c) The glass panel at the service counter shall be designed such that the passenger and the PSO staff can hear each other easily without the aid of microphone and speakers.			<input type="checkbox"/>	<input type="checkbox"/>	
(d) Motorised Aluminium Roller Shutters (with manual override) shall be provided 200mm behind the glass panel. Control Box to be provided beside the counter inside the room.			<input type="checkbox"/>	<input type="checkbox"/>	

Standard Requirements	Complied	Not Complied	Remarks
(e) For details of the Passenger Service Offices, please refer to Drawings ref L/CFADC/AR/BI/0005 to L/CFADC/AR/BI/0008.	<input type="checkbox"/>	<input type="checkbox"/>	
(f) The CCTV viewing facilities, Building Management System's (BMS) Operator Workstation and Fire Repeater Panels shall be housed in the Passenger Service Office 1.	<input type="checkbox"/>	<input type="checkbox"/>	
2.4.4 Staff Lounge cum Briefing Room			
(a) Foldable panel doors shall be provided within this room to segregate Staff Lounge and Briefing Room.	<input type="checkbox"/>	<input type="checkbox"/>	
(b) Room door shall be opened to the concourse area.	<input type="checkbox"/>	<input type="checkbox"/>	
2.4.5 Ticket Office			
(a) Doors shall be opened to the concourse area.	<input type="checkbox"/>	<input type="checkbox"/>	
(b) Laminated glass panel and half wall with customised openings incorporating service counter top shall be provided.	<input type="checkbox"/>	<input type="checkbox"/>	
(c) Width of each counter shall be 1400mm. Please refer to Drawing ref L/CFADC/AR/BI/0009 to L/CFADC/AR/BI/0010	<input type="checkbox"/>	<input type="checkbox"/>	
(d) Motorised aluminium roller shutter (with manual override) shall be provided, subject to approval by the Authority. Control Box to be provided beside the counter inside the room.	<input type="checkbox"/>	<input type="checkbox"/>	
(e) Queue railings of clear width 700mm shall be provided, with the length, layout to be approved by the Authority. The design of queue rails shall cater for sufficient waiting space for passengers-in-wheelchair. Please refer to Drawings ref L/CFADC/AR/BI/0001.	<input type="checkbox"/>	<input type="checkbox"/>	
2.4.6 Add Value Machine Room			
(a) Wall opening of size 1076mm (height) x 555mm (width) for Add Value Machine shall be provided for each room. The Please refer to Drawing ref. L/CFARC/AR/BI/0004.	<input type="checkbox"/>	<input type="checkbox"/>	
(b) The AVM Room can be combined with the Ticket Office with no separating wall, subject to Authority's approval.	<input type="checkbox"/>	<input type="checkbox"/>	
2.4.7 Commercial Space			
(a) The Commercial Spaces shall be strategically located within the concourse.	<input type="checkbox"/>	<input type="checkbox"/>	
(b) The number of compartmentalised units shall be in the range of 15 to 30sqm.	<input type="checkbox"/>	<input type="checkbox"/>	
(c) These units shall be provided with a proper frontage facing the concourse, with a minimum depth of 3m.	<input type="checkbox"/>	<input type="checkbox"/>	
(d) A maximum of 50% of these units shall be equipped with wall kitchen exhaust system and grease trap for cooking purposes.	<input type="checkbox"/>	<input type="checkbox"/>	
(e) For air-conditioned bus interchange, these units shall have walls and motorised aluminium roller shutter (with manual override).	<input type="checkbox"/>	<input type="checkbox"/>	
(f) Other commercial developments shall not front the concourse, regardless of the amount of distance setback.	<input type="checkbox"/>	<input type="checkbox"/>	
2.4.8 Canteen, Kitchen and Rodent-Free Store			
(a) The Kitchen shall be adjacent to the Canteen with the door opening to the Canteen.	<input type="checkbox"/>	<input type="checkbox"/>	

Standard Requirements	Complied	Not Complied	Remarks
(b) The Rodent-Free Store shall be adjacent to the Kitchen with door opening to the Kitchen.	<input type="checkbox"/>	<input type="checkbox"/>	
(c) The servery area in the canteen shall be provided with one double bowl sink with drainer for every 4.8sqm.	<input type="checkbox"/>	<input type="checkbox"/>	
(d) One wash basin shall be provided in the canteen.	<input type="checkbox"/>	<input type="checkbox"/>	
(e) One double bowl sink with drainer shall be provided in the kitchen	<input type="checkbox"/>	<input type="checkbox"/>	
(f) The Kitchen shall be designed for cooking purposes and equipped with kitchen exhaust system and grease trap.	<input type="checkbox"/>	<input type="checkbox"/>	
(g) Motorised full-height aluminium roller shutter (with manual override) shall be provided for the canteen entrance.	<input type="checkbox"/>	<input type="checkbox"/>	
(h) All walls in the canteen and Kitchen shall be fully tiled.	<input type="checkbox"/>	<input type="checkbox"/>	
2.4.9 Server Room			
(a) The door shall open to the Passenger Service Office 1. No window is needed.	<input type="checkbox"/>	<input type="checkbox"/>	
(b) The computer servers, CCTV backend equipment (e.g. CCTV recording facilities, CCTV network switches, etc) and BMS shall be housed in the Server Room.	<input type="checkbox"/>	<input type="checkbox"/>	
2.4.10 Staff and Public Toilet Facilities			
(a) In addition to Staff Toilets, public toilet facilities shall be provided in the concourse.	<input type="checkbox"/>	<input type="checkbox"/>	
(b) The provision of public toilet facilities, including handicapped toilet, shall comply with NEA and BFA requirements. For public male toilet, one extra set of cubicle, urinal and wash basin shall be provided, in addition to NEA's requirement.	<input type="checkbox"/>	<input type="checkbox"/>	
(c) For all toilets, including Staff Toilets, heavy-duty auxiliary facilities including hand dryer, soap dispenser, mirror, toilet fixtures, jumbo toilet roll holder, door coat hooks, sanitary napkin disposal unit (for female toilets), etc shall be provided.	<input type="checkbox"/>	<input type="checkbox"/>	
(d) Handicap toilet shall preferably be provided with a heavy-duty sliding door.	<input type="checkbox"/>	<input type="checkbox"/>	
2.4.11 Bin Centre/ Point and Electrical Substation (Outside Concourse)			
(a) A dedicated Bin Centre/ Point and Electrical Substation shall be provided in accordance with relevant authorities' requirements, with the location to be proposed for Authority approval.	<input type="checkbox"/>	<input type="checkbox"/>	
(b) The Bin Centre/ Point and Electrical Substation shall be located to facilitate efficient and safe operation of the bus interchange and shall be sheltered and away from concourse area. Footpath shall be provided for easy access, if necessary.	<input type="checkbox"/>	<input type="checkbox"/>	
(c) Vehicle lay-bys within the bus interchange space shall be provided for rubbish and power vehicles so that bus circulation and operations are not affected	<input type="checkbox"/>	<input type="checkbox"/>	
(d) Bin Centre shall be provided for refuse output exceeding 1,000L/day and shall be in accordance to NEA requirements.	<input type="checkbox"/>	<input type="checkbox"/>	
(e) Floor and walls in Bin Centre and Points shall be fully tiled.	<input type="checkbox"/>	<input type="checkbox"/>	

Standard Requirements	Complied	Not Complied	Remarks
2.4.12 Bicycle Parking Racks (Outside Concourse)			
(a) Bicycle parking racks shall be provided in the vicinity of the bus interchange.	<input type="checkbox"/>	<input type="checkbox"/>	
(b) A minimum of 40 bicycle parking racks shall be provided. Variations and addition to the number of bicycle parking racks shall be highlighted as required, dependent on the local catchment.	<input type="checkbox"/>	<input type="checkbox"/>	
(c) The location, distribution and design of the bicycle parking racks shall be proposed for Authority approval. Please refer to Drawings ref L/CFADC/AR/BI/0013 to L/CFADC/AR/BI/0014.	<input type="checkbox"/>	<input type="checkbox"/>	
2.4.13 First Aid Room cum Nursing Room			
(a) A 1m (width) x 2.1m (height) door with single door leaf and clear opening shall be provided.	<input type="checkbox"/>	<input type="checkbox"/>	
(b) One wash basin with wall mounted mirror shall be provided.	<input type="checkbox"/>	<input type="checkbox"/>	
(c) Space for baby changing facilities which include a fold down changing table, shelf and facility to dispose of soiled diapers shall be provided.	<input type="checkbox"/>	<input type="checkbox"/>	
2.4.14 Special Purpose Room			
(a) 1m long horizontal stainless steel railing fixed to back wall at 1m height	<input type="checkbox"/>	<input type="checkbox"/>	