SECTION 3.0 TECHNICAL SPECIFICATION

3.7 AIR COOLED SPLIT SYSTEM

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SECTION 3.6 AIR COOLED SPLIT UNIT SYSTEM

1.0 AIR COOLED SPLIT UNIT

Each air-cooled split unit shall consist of an air-cooled condensing unit and fan coil unit. The condensing unit shall contain hermetic compressors and the air-cooled condenser complete with fan(s) and motor drives. The fan coil unit shall contain direct expansion cooling coil/s complete with centrifugal fan(s) with drives, refrigerant controls and accessories.

The air-cooled split unit system for standard rating temperatures and minimum coefficient of performance (COP) shall be accordance with Table 1 and Table 2.

Table 1: ACMV System Equipment, Electrically Driven[1]: Standard Rating Temperatures – Cooling[2] (MS 1525:2014)

Item	Air-cooled		Water-cooled (water-source)	
	Dry-bulb	Wet-bulb	Inlet	Outlet
Room air entering equipment (^{o}C)	27.0	19.0	-	-
Condenser ambient (air-cooled) (^{o}C)	35.0	24.0	-	-
Refrigerant-water heat exchanger (^{o}C)	-	-	30.0	35.0

NOTES:

1. Data in this table apply to the following types of equipment:
   a) central Air Conditioners: Air, Evaporatively and Water Cooled, ISO 13253; and
   b) commercial/Industrial Unitary Air-Conditioning Equipment, MS ISO 5151, ISO 13253.

2. Standard ratings are also based on other standard rating conditions such as, but not limited to, electrical conditions; cooling air quantity; requirements for separated (split) assemblies; and minimum external flow resistance, as provided in the applicable standards.

Table 2 : Unitary Air Conditioners, Electrically Driven: Minimum COP – Cooling (MS 1525:2014)

Equipment		**Size**	**Sub-category**	**Minimum COP**
			Non-Inverter type	**Inverter type [1]**
Air conditioners: Air cooled with condenser	< 19 kWr	Single Split/Package	2.8	3.0
		Multi-split	2.8	3.2
	≥ 19 kWr and < 35 kWr	Split or package	2.8	3.5
	≥ 35 kWr	Split or package	2.7	2.9
Air conditioners: Water and evaporatively cooled	< 19 kWr	Split or package	3.6	4.0
	≥ 19 kWr and < 35 kWr	Split or package	3.7	4.4
	≥ 35 kWr	Split or package	3.8	4.4

NOTE:
1. The COP for the inverter unit is the weighted value, which is calculated based upon the following equation:

$$COP_{weighted} = [COP_{100\%} \times 0.40] + [COP_{50\%} \times 0.60]$$

1.1 Condensing Section

1.1.1 Compressors

The compressor shall be of hermetic Rotary type and shall be assembled complete with all necessary accessories on a steel base with vibration isolator e.g. spring-mounted type.

Compressors shall be equipped with oil failure control, dual pressure control, safety valves, suction and discharge valves, crankcase heaters, suction gas strainer, oil sight glass and other accessories if necessary. The condenser shall be suitable for condensing temperature at 48˚C (120°F) with air entering at 35˚C (95°F) DB.

The compressor and motor shall be run not more than 2900 rpm and the compressor cooling capacity rating and power rating shall be based on approved standard. The motor shall be of the AC Induction type specifically designed for operation on 400 volts (+10%,-6%), 3 phase, 50 Hz single phase electric supplies, where ever applicable.

1.1.2 Refrigerant

The refrigerant used in the split units shall be R410a or other approved environment-friendly and chlorine-free refrigerant as per schedule of design requirement

1.1.3 Condenser Fan/s and Motor/s

The condenser fan/s shall be propeller type, direct driven by heavy duty motor with aluminium blades, zinc plated steel tube and spiders, and shall have safety guards not concealed by casing.

1.1.4 Condensing Coil

The condensing coil of each condensing coil shall be extended surface direct expansion coils of factory approved, constructed from copper tube with aluminium fins or copper fins or as specified in Schedule of Design Requirement and having not less than 8 fins per 25 mm. Bonding of the fins to the tube shall be by mechanical means to ensure a positive lasting bond. The coil shall be fitted with headers and a suitable distribution network designed to produce uniform distribution of refrigerant over the face of the coils. Each header shall be fed through a thermal expansion valve and solenoid valve.

1.1.5 Condensing Unit Casing

The casing shall be fabricated from galvanized mild steel sheets properly formed for close fit and structural rigidity. The cabinet frame shall be all-welded. All access panels shall be so constructed as to be easily removable. All inside and outside

surfaces of the cabinet shall be wear-resistant baked-on enamel, attractively finished.

1.1.6 Condensing Unit Bracket/Support

All condensing units shall be properly supported and anchored to the building structure using galvanized steel brackets and supports which shall be fixed to the building structure by means of inserts or expansion shields of adequate size and number to support the loads imposed there on.

1.1.7 Anti Corrosion Coating for Marine Condition (if required)

All aluminium fins for the condensing coil shall have **anti corrosion coating** able to withstand 1000 hours salt spray test run in accordance with JIS-Z-2371, 1988.

The condensing unit casing, bracket and support shall in addition be protected with anti-corrosion coating. The anti-corrosion coating material and method statement shall be approved by S.O.

1.2 Fan Coil Section

1.2.1 Casing Construction

The fan coil unit housing shall be constructed from hard plastic reinforced and braced with steel angle framework for maximum rigidity. Each unit shall have predrilled flanges with identical hole locations to permit easy assembly of adjoining sections or modules.

1.2.1 Insulation For Casing Of Ceiling Cassette Fan Coil Unit

The casing for the fan coil unit (ceiling cassette type) in the ceiling space immediately below the roof and non-conditioned area shall be externally insulated with not less than 10 mm thick, closed cell nitrile rubber to . The closed cell nitrile rubber insulation shall have density of not less than 55 kg/m^3 and shall have thermal conductivity not more than of 0.036 W/mK. The closed cell nitrile rubber insulation shall be fire-retardant and the insulation material shall be approved by Jabatan Bomba dan Penyelamat Malaysia.

1.2.2 Evaporator Cooling Coils

The cooling coils of each unit shall be extended surface direct expansion coils of approved manufacture, constructed from copper tube with aluminium fins or as specified in Schedule of Design Requirement and having not less than 8 fins per 25mm. Bonding of the fins to the tube shall be by mechanical means to ensure a positive lasting bond. The coils shall be fitted with headers and a suitable distribution network designed to produce uniform distribution of refrigerant over the face of the coils. Each header shall be fed through a thermal expansion valve and solenoid valve.

1.2.3 Centrifugal Fan

The fan/s of each unit shall be double width, double inlet, multi-blade centrifugal type. All fans shall be statically and dynamically balanced and tested after being installed on properly sized hollow or solid shafts. The fan housings shall be constructed with die-formed streamlined inlets and side sheets.

The maximum outlet velocity of the fans shall not exceed 9.1 m/s (1800 fpm). The fans shall be either forward curve or backward inclined and airfoil depending on the sizes.

1.2.4 Air Filters

The air filters for the unit shall be with an average Dust Extraction Efficiency on A.F.I. Test of at least 80% and washable. Test certificate for the above condition shall be made available. Filters shall be arranged in banks in sufficient numbers to operate on the correct manufacturer's rating. The filter frame shall consist of an outer section able to be permanently mounted and a quick release removable gate section from which the filters only can be removed for changeover and washing. The frame shall be fabricated from 1.25mm thick zinc coated annealed steel, phosphated after fabrication, prime etched and enamel paint finished. Heavy aluminium frames may also be used. The filters shall be supported on both sides by 12 gauge wire mesh at intervals of not more than 100mm apart in each direction.

1.2.5 Remote Controller

The air cooled split unit controllers shall be mounted in an individual casing. Individual wired at maximum height of 1.5 meter from floor level or wireless remote controller shall be provided. All controllers shall be of factory-assembled and tested.

1.2.6 Anti-Recycle Protection

The system shall be coupled with anti-recycle protection to prevent the compressor to restart again immediately after it was stopped.

2.0 PIPEWORKS

2.1 General

The work involved includes but shall not be limited to the supply and installation of all necessary pipe, valves, fittings, anchors, supports, brackets, insulation etc. unless specifically excluded elsewhere in this Specification.

The pipework shall be carried out by competent person in accordance with the best engineering practice to conform the diagrams and layouts shown in the Tender Drawings.

2.2 Regulations

All pipelines shall be constructed in accordance with the relevant Regulations and Standard.

2.3 Type of Pipes

2.3.1 Refrigerant Piping

All refrigerant pipes for the air-conditioning system shall be constructed from hard drawn seamless copper refrigerant pipes with copper fittings and silver soldered joints.

The refrigerant piping arrangements shall be in accordance with good practice within the air-conditioning industry, and are to include expansion valves, solenoid valves, shut off valves, strainers, sight glass, charging connections, suction line insulation and all other such items normally forming part of proper refrigerant circuits.

The sizes of the refrigerant piping shall conform to the requirements of the system capacity specified.

The Air-Conditioning Contractor will be entirely responsible for the correct refrigerant piping design and the proper interconnections of the complete refrigerant circuit.

The suction line pipe size, the hot-gas line pipe size and the liquid line pipe size shall not be less than the manufacturer's specified outside diameter.

All refrigerant pipes shall be properly supported and anchored to the building structure using steel hangers, anchors, brackets and supports which shall be fixed to the building structure by means of inserts or expansion shields of adequate size and number to support the loads imposed there on.

Complete charge of refrigerant and approved refrigerant oil for the normal operation of the air-conditioning system shall be furnished and installed by the Air-Conditioning Contractor.

Where refrigerant piping above 80mm O.D has to be used, then the refrigerant piping

may be constructed from extra heavy quality black iron steam pipes with welded joints, in lieu of hard drawn copper refrigerant pipes.

Up to and including 50mm bore, pipes shall be seamless copper to BS 659. Above 65 mm (2½") bore pipes shall be galvanized steel heavy gauge to BS EN 10255:2004.

2.3.2 Drain Pipes

Drain pipes shall be of PVC Class C for all sizes.

2.4. Insulation of Pipes

2.4.1 Refrigeration Pipe

The whole of the liquid and suction refrigerant lines including all fittings, valves and strainer bodies, flanges, etc. shall be insulated with minimum 25 mm thick closed cell flexible expanded rubber compound or approved equivalent.

2.4.2 Drain Pipe

All drain pipe carrying condensate water from AHU/FCU shall be insulated with 25 mm thick closed cell flexible expanded rubber compound to prevent condensation.

3.0 VENTILATION AND EXHAUST SYSTEMS

3.1 Exhaust Fan

All exhaust fans shall be of the propeller or centrifugal type as indicated in the Schedule of Design Requirement. Each fan shall be capable of continuous operation and shall have a capacity as indicated in the Schedule Design Requirement and in the accompanying drawings, when running at the speed specified against the friction in the system.

The exhaust fans shall be manufactured from PVC or plastic type fans and shall be accurately balanced on bright steel shaft in ball or sleeve bearings. The fans shall be window-mounted or wall-mounted to suit the particular installations. Wall mounted fans shall be supplied with wall boxes and wall plates suitable for removal for cleaning, or built-in wall where shown in the accompanying drawings.

The fan motors shall be suitable for operation on single phase, 230V (+6%,-10%) and 50 cycles supply. Where specifically indicated controllers and/or suitable speed regulators giving a minimum of 3 forward speeds and 'off' shall be supplied.

3.1.1 General Exhaust System

General exhaust system shall be supply and install as per tender drawings and Schedule of Design Requirement. The exhaust system supply and install shall be in accordance with good engineering practice and shall be most suitable to the application or desired objectives.

3.1.2 Ducts and Fittings

All ductwork, diffusers, grilles, dampers, quadrants, insulation hangers, supports and all other accessories shall be supply and install as indicated in the tender drawings.

For all ducts that are exposed to the outside, they shall be fitted with weather proof hood or cover.

All exhaust ductwork shall have all seams and joints completely soldered air-tight in order to achieve satisfactory pressurization control in the specified area. If necessary, flange joints may be used.

Exhaust duct shall be internally lined for a distance of at least 3 m from the fan with 25 mm thick fire resistant fiberglass of 32 kg/m³ (2 lb/ft^3) density and having a thermal conductivity of not more than 0.0332 W/mK

or with 25 mm thick open cell PU foam of density not less than 40 kg/m^3 and thermal conductivity of not more than 0.02 W/mK.

or with PE foam of not less than 12.0 mm thick and having a thermal conductivity of not more than 0.036 W/mK. The PE foam material shall be chemically or physically cross linked open-cell type with a density of not less than 33 kg/m^3 and faced on one side with appropriate thickness factory applied reinforced sheet metal.

The above insulation shall be covered to prevent erosion with a closely perforated fire resistant reinforced aluminium foil or a perforated light gauge sheet metal/jacket. The aluminium foil shall be glued to the fiberglass with an approved adhesive

All exhaust duct passing through air condition area shall be external insulated as per Section 3.1.9: Insulation Of Sheet Metal Ductwork.

All other application of air ductwork shall comply to the requirement of this section.

3.1.3 Interlocking Devices

Interlocking devices shall be supplied and installed as indicated in the drawing and Schedule of Design Requirement.

The interlocking devices shall operate in such a way, that, fans associated with each air conditioning zone or function unit shall be interlocked as a group with the fans to operate when the unit is operating and to stop when the unit stops.

3.1.4 Fan Switches

Fan switches shall be supply and install at the location as indicated in the drawings. A power supply connection terminated to an isolator will be provided under Electrical Works. All the wiring necessary from the isolator onwards to all the A/C equipment shall be done by the Contractor. The type of switches is also described in the drawing and the Schedule of Design Requirement.

4.0 ELECTRIC MOTORS

4.1 General

All electric motors shall be drip proof, fan cooled and fully tropicalized, and shall be furnish with Class "E" insulation to BS 2757 and BS 2613 and shall be specifically designed for operation on 50 cycles electric power supplies. All electric motors shall be furnished with isolator gears and appropriate starter gears which shall be fully tropicalized and comply with BS 587.

All motors of 1.1 kW and above shall be wound for 400V/3 ph/50 Hz electric supply. All motors less than 1.1 kW shall be designed for 230V/1ph/50Hz electric supply.

Thermal overload protection devices in all phases, over current devices and under voltage releases shall be furnished and incorporated in the circuits of all the electric motor.

4.1.1 Output Rating and Duty

Unless specific circumstances apply, motor continuous rating should not normally exceed 30% of its estimated maximum load.

4.1.2 Motor Efficiencies

All A.C. 2 pole, 4 pole and 6 pole, 3 phase induction motors, in the range 1.1 to 90 kW shall be high efficiency motors, EFF1 or EFF2 classified under MS1525:2014 as shown in Table 4, Table 5 and Table 6. Selection of efficiency class shall be as follows;

Table 3: Selection of Efficiency Class

Application	Efficiency Class
Chilled Water Pump	EFF1
Condenser Water Pump	EFF1
Cooling Tower Fan	EFF1
AHU Blower Fan	EFF1
Exhaust Fan	EFF1

Motor energy efficiencies are to be tested according to MS IEC60034-2:2005 or its latest edition.

Table 4: Efficiency Class Definition for 2-Pole Motors (MS 1525:2014)

Motor Capacity (kW)	Motor Efficiency (%)		
	Motor Class IE3	**Motor Class IE2**	**Motor Class IE1**
0.75	80.7	77.4	72.1
1.1	82.7	79.6	75.0
1.5	84.2	81.3	77.2
2.2	85.9	83.2	79.7
3	87.1	84.6	81.5
4	88.1	85.8	83.1
5.5	89.2	87.0	84.7
7.5	90.1	88.1	86.0
11	91.2	89.4	87.6
15	91.9	90.3	88.7
18.5	92.4	90.9	89.3
22	92.7	91.3	89.9
30	93.3	92.0	90.7
37	93.7	92.5	91.2
45	94.0	92.9	91.7
55	94.3	93.2	92.1
75	94.7	93.8	92.7
90	95.0	94.1	93.0
110	95.2	94.3	93.3
132	95.4	94.6	93.5
160	95.6	94.8	93.8
200	95.8	95.0	94.0
220	95.8	95.0	94.0
250	95.8	95.0	94.0
300	95.8	95.0	94.0
330	95.8	95.0	94.0
375	95.8	95.0	94.0

Table 5: Efficiency Class Definition for 4-Pole Motors (MS 1525:2014)

Motor Capacity (kW)	Motor Efficiency (%)		
	Motor Class IE3	**Motor Class IE2**	**Motor Class IE1**
0.75	82.5	79.6	72.1
1.1	84.1	81.4	75.0
1.5	85.1	82.8	77.2
2.2	86.7	84.3	79.7
3	87.7	85.5	81.5
4	88.6	86.6	83.1
5.5	89.6	87.7	84.7
7.5	90.4	88.7	86.0
11	91.4	89.8	87.6
15	92.1	90.6	88.7
18.5	92.6	91.2	89.3
22	93.0	91.6	89.9
30	93.6	92.3	90.7
37	93.9	92.7	91.2
45	94.2	93.1	91.7
55	94.6	93.5	92.1
75	95.0	94.0	92.7
90	95.2	94.2	93.0
110	95.4	94.5	93.3
132	95.6	94.7	93.5
160	95.8	94.9	93.8
200	96.0	95.1	94.0
220	96.0	95.1	94.0
250	96.0	95.1	94.0
300	96.0	95.1	94.0
330	96.0	95.1	94.0
375	96.0	95.1	94.0

Table 6: Efficiency Class Definition for 6-Pole Motors (MS 1525:2014)

Motor Capacity (kW)	Motor Efficiency (%)		
	Motor Class IE3	**Motor Class IE2**	**Motor Class IE1**
0.75	78.9	75.9	70.0
1.1	81.0	78.1	72.9
1.5	82.5	79.8	75.2
2.2	84.3	81.8	77.7
3	85.6	83.3	79.7
4	86.8	84.6	81.4
5.5	88.0	86.0	83.1
7.5	89.1	87.2	84.7
11	90.3	88.7	86.4
15	91.2	89.7	87.7
18.5	91.7	90.4	88.6
22	92.2	90.9	89.2
30	92.9	91.7	90.2
37	93.3	92.2	90.8
45	93.7	92.7	91.4
55	94.1	93.1	91.9
75	94.6	93.7	92.6
90	94.9	94.0	92.9
110	95.1	94.3	93.3
132	95.4	94.6	93.5
160	95.6	94.8	93.8
200	95.8	95.0	94.0
220	95.8	95.0	94.0
250	95.8	95.0	94.0
300	95.8	95.0	94.0
330	95.8	95.0	94.0
375	95.8	95.0	94.0

4.1.3 Power Factor Requirement

All motor from 2 hp. to 100 hp. shall have a power factor of not less than 0.85 at 80% loading.

Motors over 100 hp. shall have a power factor of not less than 0.90 at 80% loading.

The above condition is to be achieved by power factor improvement equipment or devices. However, if the power factor correction is done other than at the load, than the cabling, electrical switching protection devices between the load and the point of correction shall be rated according to the worst power factor condition that they may be subjected to.

Power factor improvement equipment used shall conform to IEC 70/70A standards and shall be suitable for continuous operation at a normal voltage of 400 volts (+10%,-6%), 3 phase, 50 Hz.

Capacitors used shall be dry type with self-healing properties and discharge devices. Loss shall not exceed 0.5 kVAr.

When automatic power factor correction bank is used, the regulator with the required number of steps should also incorporate no volt protection relay, anti-hunting relay and a manual and automatic control switch. The regulator should be set to respond to kVAr need of the system with no hunting. The regulator shall have LED display to show the number of steps switched ON at any one time and settings for the sensitivity value and the desired power factor.

Current transformer to suitable ratio shall be rated at 15 VA and minimum accuracy of Class 1.

A kW-hr meter and a kVAr meter shall be incorporated in switchboards with a connected total load of 50 kW and above.

This Contractor shall be liable to pay any surcharge, or part thereof, levied by the Tenaga Nasional as a consequence of low power factor of the installed equipment.

5.0 NOISE AND VIBRATION CONTROL

This section of specification specifies the basic requirement that the noise and vibration isolation control for the mechanical equipment which must be satisfied in order to be considered for the installation.

All mechanical plant and services shall be installed in accordance with the methods of installation and precautions stated herein, and such additional precautions as may be necessary to ensure that the operation of the plant does not result in noise levels or vibration amplitudes beyond the specified limits.

5.1 Description of System

The work specified under this section shall include but not necessarily limited to the following:

1. All noise and vibration generated by mechanical equipment shall be isolated from the building structure.

2. All piping and ductwork in the building which is connected to vibration isolated equipment shall be isolated at connections to the building structure.

3. All piping and ductwork in equipment rooms and up to 15m from vibrating equipment shall be isolated from the building structure by means of noise and vibration isolation hanger, guides and supports.

4. All piping and ductwork vertical risers shall be isolated from the building structure by means of noise and vibration isolation guides and supports.

5. All piping and ductwork to be isolated according to this section of the specifications shall freely pass through walls and floors without rigid connections. Penetration points shall be sleeved or otherwise formed to allow passage of piping or ductwork, and maintain a minimum of 25mm (1”) and maximum of 50mm (2") clearance around the outside surfaces. This clearance space shall be tightly packed with fibrous material or with engineered pipe penetration seals and shall be caulked airtight and water proof after installation of the piping or ductwork.

The whole of the work, including the particulars and/or deviations shown on the drawings and/or specified in the following clauses shall be in accordance with the appropriate ASHRAE Standards or such other National Standards as may be approved by the SO.

5.2 Design Standards and Verifications

The design of noise and vibration control equipment shall comply and not limited to the following Codes and Authorities:

1. ASHRAE 2003 (Chapter 47 – Noise and Vibration Control)
2. SMACNA
3. ARI 885 – 1998

Submittals and data requirements:

1. Descriptive Data:

    a. Schedules of equipment isolator.
    b. Catalogues and data sheets on vibration isolators.

2. Detailed and dimensioned Working Drawings including:

    a. Details of equipment bases including dimensions, structural member sizes and support point locations.
    b. Details of isolation hangers for ceiling hung equipment, piping and ductwork.
    c. Details of mountings for floor supported equipment, piping and ductwork.
    d. All hanger, mounting or pad drawings shall indicate deflections and model numbers as well as any other requirements in the specifications.
    e. Spring diameters, rated loads and deflections, heights at rated load and closed height shall be provided for all springs shown in the submittals in tabular form.
    f. Complete flexible connector details.

5.3 Noise Control

The sound power levels of the equipment shall be carefully examine as well as construction and installation methods to ensure that the equipment selection meets the sound level required.

All adjustments, modifications and testing shall be carried out to achieve the specified noise level. All supplied equipment from which noise is emanated shall be selected such that specified noise levels are not exceeded or shall be fitted with approved sound attenuation.

Optional room insulation using panel fitted to the all walls and doors with exceptional of fire rated door at the Mechanical Plant room shall be thermally and acoustically insulated with size and dimensions as per design requirement.

All rotating machine shall be properly balanced and shall be designed with clearances and mechanisms suitable for the noise level requirements.

Rotating machinery shall be mounted on approved vibration isolating mountings. The

mountings shall be protected from drips and damage, and where necessary, additional mass shall be fixed to the machinery to damp vibration.

The loading of the mounting shall be adequate to ensure correct operation. Materials used to seal the spaces containing the isolating materials shall be flexible so that vibration is not transmitted and the seal is not damaged.

All connections to rotating machinery shall be of flexible type. Duct connections shall be isolated by flexible nylon fabric or canvas connections.

Pipe connections shall be suitably flexed for the duty involved. Approved flexible connectors shall be provided where insufficient flexibility can be transmitted to the building structure. Flexibility connectors shall be so positioned that no stressed can be put on the pipes due to end reaction.

Electric motors for all air conditioning unit and ventilation fans shall be quiet in operation to deliver noise level criteria as set out in Table 7 & 8.

On completion of the installation, precise measurements of the noise levels in the various areas shall be made. Octave band sound pressure levels in the various areas within the building and at certain positions outside the building due to the operation of the equipment included in this contract shall not exceed the noise level criteria set out in the Table 7 & 8.

In the event when the space noise exceeding maximum level of table 7 & 8 above, the level data should be allowed to be offset of 10dB /10 NC of background noise.

Where dispute arises over the classification of any area under the following schedule the S.O. determination of the space type and function of the area, as listed in Table 7 & 8, shall be final.

Table 7: Recommended Noise Criteria (NC) – Room Criteria (RC) and Maximum Sound Pressure Level (Lp) for Different Indoor Activity

Type of Area	Max Level	
	NC-RC Level	Lp (dBA)
RESIDENCES		
Residences, Apartment, Condominium	**35**	**40**
HOSPITALS & CLINICS		
Private rooms	**35**	**40**
Operating rooms	**40**	**45**
Wards, corridors	**40**	**45**
Laboratories	**40**	**45**
Lobbies, waiting rooms	**45**	**50**
Washrooms, toilets	**50**	**55**
OFFICES		
Board rooms	**30**	**35**
Conference rooms	**35**	**40**
Teleconference rooms	**25**	**30**
Executive offices	**40**	**45**
General offices	**40**	**45**
Reception rooms	**45**	**50**
General open offices	**45**	**50**
Drafting rooms	**45**	**50**
Halls & corridors	**60**	**65**
Tabulation and computation areas	**50**	**55**
AUDITORIUMS		
Multi-purpose halls	**30**	**35**
Lecture halls	**35**	**40**
Planetariums	**35**	**40**
Lobbies	**45**	**50**
LABORATORIES (with fume hoods)		
Testing/research, minimal speech communication	**55**	**60**
Research, extensive telephone use, speech communication	**50**	**55**
Group Teaching	**45**	**50**

Table 8: Recommended Noise Criteria (NC) – Room Criteria (RC) and Maximum Sound Pressure Level (Lp) for Different Indoor Activity (cont').

Type of Area	Max Level	
	NC-RC Level	Lp (dBA)
PERFORMING ARTS SPACES		
Drama Theaters	**25**	**30**
Concert and recital halls	**25**	**30**
Music Teaching Studios	**25**	**30**
Music Practice Rooms	**35**	**40**
MASJID / RUMAH IBADAT	**35**	**40**
SCHOOLS		
Lecture/Classrooms	**40**	**45**
Classrooms up to 750 ft^2 [75 m^2]	**40**	**45**
Classrooms over 750 ft^2 [75 m^2]	**35**	**40**
Lecture rooms for more than 50 (unamplified speech)	**35**	**40**
Laboratories	**45**	**50**
Recreation halls	**50**	**55**
Corridors & halls	**50**	**55**
PUBLIC LIBRARIES		
Libraries, museums	**40**	**45**
COURT ROOMS	**40**	**45**
i) Unamplified speech	**35**	**40**
ii) Amplified speech	**40**	**45**
RESTAURANTS, CAFETARIA		
Restaurants	**45**	**50**
Cafeterias	**50**	**55**
INDOOR SPORTS ACTIVITIES		
Gymnasiums	**45**	**50**
School and college gymnasiums	**50**	**55**
Large seating capacity spaces (with amplified speech)	**55**	**60**
AIRPORT		
Tickets sales offices	**40**	**45**
Lounges, waiting rooms	**50**	**55**
OUTSIDE MECHANICAL PLANT ROOM		
1m away from external wall	**70**	**75**

5.4 Vibration Control

The vibration isolation shown on the drawings and Specification is as per minimum requirement. The installed equipment isolator shall be able to damp the vibration to the magnitude as per manufacturer's recommendation.

All vibration isolation shall be mounted on vibration isolators and complete with the flexible connections to prevent the transmission of vibration and noise to the building structure. Vibration isolators shall be selected in accordance with the weight distribution.
Mountings installed outdoor shall be protected from corrosion as per recommended by manufacturer with a minimum of cold galvanizing paint if not specified. For corrosive environment, the minimum requirement shall be of hot dipped galvanized.

The isolators installed for all mechanical equipment shall have a minimum deflections as per listed in the Vibration Isolators in Table 9 below. Any dispute arises in Table 9; all decision shall be referred and decided by S.O.

Table 9: Vibration Isolators Schedule

Equipment	Isolators	Remarks
Centrifugal, Screw and Reciprocating Chiller	1. Restrained type steel spring in series with a layers on top and bottom plate each 9.0mm minimum thick neoprene pads / natural rubber. 1.1 When equipment on stable ground minimum deflection is 19mm. 1.2 When equipment on concrete slab above floor level the minimum deflection is 38mm.	a) There should not be any rigid ties to any structure. All connection shall be flexible. b) All pipe work within the plant room shall have steel spring hangers of min 25 mm total static deflections in series with neoprene.
Chilled Water Pump, Condenser Water Pump and All Other (End Suction, Split Casing, and Others)	1. Un-housed type steel spring in series with a layer of 9.0mm minimum thick neoprene pads / natural rubber. 1.1 When equipment on stable ground minimum deflection is 19mm. 1.2 When equipment on concrete slab above floor level the minimum deflection is 38mm. 2. Inertia block shall be according to operation weight ratio (min 1:1.2 ratio) and min 150mm thick.	a) There should not be any rigid ties to any structure. All connection shall be flexible. b) All pipe work within the plant room shall have steel spring hangers of min 25 mm total static deflections in series with neoprene. c) The inertia blocks shall be large enough to support the pipe work including the first elbow.
Cooling Towers	1. Restrained type steel spring in	a) There should not be any

	series with a layers on top and bottom plate each 9.0mm minimum thick neoprene pads / natural rubber. 1.1. When equipment on stable ground minimum deflection is 19mm. 1.2. When equipment on upper floor or critical area above floor level the minimum deflection is 89mm.	rigid ties to any structure. All connection shall be flexible. b) All pipe work connected to cooling towers shall have flexible joints.
Air Handling Unit	1. A layer of minimum 9.0mm thick neoprene pad 2. For critical area, un-housed type steel springs in series with a layer of 9.0mm minimum thick neoprene pads / natural rubber.	a) There should not be any rigid ties to any structure. All connection shall be flexible. b) All pipe work within the plant room shall have steel spring hangers of min 25 mm total static deflections in series with neoprene. c) Pipe work to equipment shall have flexible joints. d) All ductwork to equipment shall have flexible connection.
Fan coil units (Up to 7.5kW)	1. Spring isolators (floor or hanger type) of minimum 19mm deflections.	a) There should not be any rigid ties to any structure. All connection shall be flexible b) All ductwork to equipment shall have flexible connection
Fan Coil Units (11kW and above)	1. Spring isolators (floor or hanger type) of minimum 89mm deflections.	
Condensing Units	1. Floor mounted unit – A layer of minimum 9.0mm thick neoprene pad. 2. Suspended type – spring isolators of minimum 38mm deflections.	a. There should not be any rigid ties to any structure. All connection shall be flexible. b. Pipe work to equipment shall have flexible connections.
Mechanical	1. Double deflection steel spring with	a) There should not be any

Ventilation Fan (Axial, Centrifugal, Fan Heads, Cabinet Fans, Fan Sections) – up to 560mm dia	neoprene element in shear hanger of supports of min 19mm deflections.	rigid ties to any structure. All connection shall be flexible. b) All ductwork to equipment shall have flexible connection (if any).
Mechanical Ventilation Fan (Axial, Centrifugal, Fan Heads, Cabinet Fans, Fan Sections) – 610mm dia and above	1. Un-housed type steel spring in series with a layer of 9.0mm minimum thick neoprene pads / natural rubber with minimum 19mm deflection. 2. Inertia block shall be according to operation weight ratio (min 1:1.2 ratio) and min 150mm thick.	
Propeller Fan	1. A layer of minimum 9.0mm thick neoprene pad.	a) There should not be any rigid ties to any structure. All connection shall be flexible.

5.5 Piping

Equipment installed on vibration isolators exhibits some motion or movement from pressure thrusts during operation. Vibration isolators have even greater movement during starting-up and shutdown. The piping system shall be flexible enough to:

i) Reduce vibration transmission along the connected piping.

ii) Permit equipment movement without reducing the performance of vibration isolators.

iii) Accommodate equipment movement or thermal movement of piping at connections without imposing undue strain on the connections and equipment.

In general, water pipes shall be sized to maintain average flow velocities of not more than 2.2 m/s. Flow velocity at 12 m/s maximum for pipe 50mm and smaller. A pressure drop limitation of 4 ft of water per 100 ft of pipe length with a maximum velocity of 3.0 m/s for larger pipe sizes.

Isolation hangers shall be used for all piping in mechanical equipment rooms and up to 15 m from vibrating equipment.

The first three isolation hangers/supports from all mechanical equipment should provide the same deflection as the equipment isolators, with a maximum limitation of 50mm deflection.
The remaining isolation hangers within 15 m should be spring or combination spring and rubber with minimum of 20mm deflection.

The first vertical pipe riser entering the building shall be supported by spring isolators

designed to support the riser filled with water, if it is a water line.

Assigned loads must be within the building design limits at the support points. Neutral central resilient anchors close to the center of the run shall direct movement up and down.

The anchors and guides must be rigidly attached to the structure and shall be capable of holding an upward force equal to the water weight when the system is drained. The remaining vertical pipe riser shall be supported by natural rubber/ neoprene pad with minimum thickness of 9 mm.

All pipe penetrations through wall; floors and ceiling shall be isolated from direct contact with the structure.

5.6 Ductwork

The main supply air ductwork shall be internally insulated with acoustic insulation for the length as specified in the tender drawing. If unspecified, it shall be taken as 5m from the fan or 1m beyond the first bend, whichever is the longest.

Isolation hangers shall be used for all ductwork in mechanical equipment rooms and up to 15 m from vibrating equipment. The first three isolation hangers/supports from all mechanical equipment should provide the same deflection as the equipment isolators, with a maximum limitation of 50mm deflection. The remaining isolation hangers within 15 m should be spring or combination spring and rubber with minimum of 20mm deflection.

The acoustic performance of the fiberglass internal insulation of duct shall not be less than those stated in the Table 10 below for the thickness indicated and in accordance to BS EN 20354 / BS 3638. The air erosion resistance for the internal insulation shall not be less than 2500 fpm and comply with ASTM C1071-05e7 and ASTM C1534-07.

Table 10: Absorption Coefficient

Frequency, Hz	125	250	500	1000	2000	4000	NRC
Absorption Coefficient (25mm)	0.08	0.20	0.56	0.93	0.84	0.92	0.63
Absorption Coefficient (50mm)	0.19	0.49	0.87	0.97	0.97	1.04	0.83

6.0 ELECTRICAL WORKS

6.1 General

The Contractor shall carry out all electrical work necessary for the efficient, safe and satisfactory operation of the plant detailed elsewhere in the specification and shall supply, install and connect all motors, switchboards, switchgears and all necessary equipment and materials except where it is stated in the specification that materials are to be supplied or work is to be carried out by others.

All electrical equipment supplied shall be of the first grade as regards design and fully competent electrician of appropriate grades shall only carry out manufacture and installation.

All the electrical work shall use JKR approved product listed on J-MAL / Electrical Material Approval List.

The Contractor shall provide the following electrical equipments and services:

(a) All electric motors, starters, cable boxes and isolating switches for the air conditioning and ventilation services.

(b) Conduit, cable tray, cabling and control wiring from the electrical in the sub-switchboards to the air conditioning switchboards (control panels).

(c) Conduit, cable tray, cabling and control wiring from the air conditioning switchboards (control panels) to the various items of air conditioning and ventilation equipments.

(d) All control equipments, control wiring and associated works.

(e) Conduit and wiring including control switches and fused spare outlets as indicated in the tender drawings.

(f) Relays for FF detectors in the AC Control Panel/Switchboard.

The Contractor shall be required on completion of the electrical installation to provide in a glazed frame a complete "as installed" wiring diagram identifying all the control circuit and the various colour-coding. The diagram endorsed by a competent person or manufacturer.

The following works shall be carried out under other specialist work:

(a) Supply, installation and connection of the sub-mains to main air conditioning plant switchboard and to the isolators in the sub-switchboards for the AHUs.

(b) Lighting and power socket outlets in the plant rooms.

Unless specified elsewhere, all equipment, apparatus, appliances and accessories for low voltage electrical installation shall be rated for operation on a 240/415 V (within the tolerance as defined in MS IEC 60038 : 230/400V (+10%,-6%), 3 phase, 50 Hz. system with solidly earthed neutral.

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

6.2 Main Air Conditioning Switchboard

6.2.1 Types of Air Conditioning Switchboard

The types of switchboard shall be as specified in the Drawings and/or Schedule of Design Requirements shall be of the following types:

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

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

(c) Wall mounted metalclad type suitable for front access.

The switchboards shall house their air circuit breakers, moulded case circuit breakers, fuse switches, switch fuses, isolators, contactors, busbars, meters, protective relays, selector switches, indicating lamps, current transformers, cable terminating boxes, cable glands, anti-condensation heaters complete with automatic thermostats and isolators and all other necessary items of equipment whether specified hereinafter or in the

Drawings or not, suitable for operation on a 400/230 V (+10%, -6%), 3 phase, 50 Hz. system with solidly earthed neutral.

Unless otherwise specified elsewhere, the switchboards shall be capable of withstanding fault condition of not less than 50 kA at 415 V for 1 s as defined in IEC 60439-1.

The switchboards shall comply with IEC 60439-1 and the degree of protection shall be IP41 in accordance to MS IEC 60529.

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

Type testing for switchboard:-

Table 11: Type Testing For Switchboard As Per Categorization

Category	Current Rating	Registration & Type Test Report
I	I ≤ 600A	SuruhanjayaTenaga
II	600A < I ≤ 2000A	SuruhanjayaTenaga& Partial Type Test accordance with MS IEC 60439-1 (i) Short Circuit Test (Clause:80203) (ii) Temperature Rise Test (Clause:8.2.1)
III	I > 2000A	SuruhanjayaTenaga& Full Type Test accordance with MS IEC 60439-1

Routine tests on the switchboard shall be carried out before delivery to site. The main circuits and the auxiliary circuits shall be tested to verify dielectric properties with power-frequency test voltage of 2500 V*ac* for 1 minute and insulation resistance under test voltage of 1000 V. Routine tests shall include inspection and checking of wiring, electrical continuity of the protective circuits, connections and effectiveness of mechanical actuating elements and interlock.

Test Results or Certificate duly certified by Competent Person as in Electricity Regulations 1994 shall be issued for every switchboard supplied and installed.

6.3 Power Factor Requirement for Main Switchboard

All switchboard equipment such as motor, transformer, air conditioners, fans, refrigerator, welders fluorescent light, etc. below 132kVA. shall have a power factor of not less than 0.85 at 80% loading.

Switchboard equipment's with capacity over 132 kVA shall have a power factor of not less than 0.90 at 80% loading.

The above condition is to be achieved by power factor improvement equipment or devices. However, if the power factor correction is done other than at the load, than the cabling, electrical switching protection devices between the load and the point of correction shall be rated according to the worst power factor condition that they may be subjected to.

Power factor improvement equipment used shall conform to IEC 70/70A standards and shall be suitable for continuous operation at a normal voltage of 415 V and up to 440 V, 50 Hz, 3 phase.

Capacitors used shall be dry type with self-healing properties and discharge devices. Loss shall not exceed 0.5 kVAr.
When automatic power factor correction bank is used, the regulator with the required

number of steps should also incorporate no volt protection relay, anti-hunting relay and a manual and automatic control switch. The regulator should be set to respond to kVAr need of the system with no hunting. The regulator shall have LED display to show the number of steps switched ON at any one time and settings for the sensitivity value and the desired power factor.

Current transformer to suitable ratio shall be rated at 15 VA and minimum accuracy of Class 1. A kW-hr meter and a kVAr meter shall be incorporated in switchboards with a connected total load of 50 kW and above.

This Contractor shall be liable to pay any surcharge, or part thereof, levied by the Tenaga Nasional as a consequence of low power factor of the installed equipment.

6.4 Enclosures

6.4.1 General

Switch operating handles shall be interlocked with the compartment door so that the door may not be opened until the switch is off.

Light shall be clearly visible at a distance on clear day. The following shall be incorporated in Switchboard but not limited to:

(1) Duty & Standby Pump:

i) Red, Yellow and Blue lights for phase indication in duplicate.

ii) Red flashing light for A/C FAIL and PUMP ON MANUAL.

iii) Green light for PUMP RUN.

iv) Yellow light for PUMP TRIP.

v) START and STOP push button.

vi) Switch off for A/C isolate and AUTO MANUAL selector switch.

vii) An ammeter and voltmeter shall be provided.

viii) MANUAL START push button.

ix) Amber light for AUTO ON, AUTO CRANK ON, MANUAL ON, and AUTO CRANK FAIL.

x) Green light signals shall be provided on single horizontal alignment spaced adequately to show that the supply is normal. They are A/C ON, CHARGER ON, D/C ON.

(2) A relay shall be provided in the switchboard to stop the pump when the water level in the water tank is at low water level and prevent from being switch on again until the water level reach start level.

6.5 Self-Contained Floor Mounted Cubicle Switchboards

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

The front shall be provided with covers/doors of box formation. The rear shall be provided with hinged removable doors of box formation. The rear doors shall be of double-leaf type with rebated edges and each leaf should preferably not be wider than 450 mm. Each leaf of door shall have 2 pairs of approved hinges. The door shall be fitted with approved type of surface-mounted espagnolette or cremone bolts complete with approved locking device operated by a satin chrome lever handle at the centre fixing. The top and sides shall be of removable panels. Cover plates with openings for cable entry shall be provided at the base of the switchboard. All panels, covers and doors shall be fabricated from sheet steel of thickness not less than 2.0 mm and so constructed as to provide a clear, flush and pleasing appearance. The panels, covers and front doors shall be secured to the enclosure by means of chromed type of screws with cylindrical knurled head complete with retaining clips. Welded cross struts shall not be used.

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

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

A lockable tool compartment with keys and opening handle shall be provided at the lowest subsection of the switchboard. The switchboard shall undergo de-rusting treatment, anti-rust treatment with the exterior finished with epoxy dry-powder and oven baked semi-gloss beige colour and interior finished matt white. The switchboard shall be bolted to mild steel channel base or over concrete trench. The channel shall be anti-rusted and painted with a primer. There shall be a readily installed cable tray on the interior at both side panels for outgoing cable. All cables shall be rigidly secured using cable support bracket of non-rotting material, before termination.

6.6 Wall Mounted Switchboards

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

The front cover of the switchboard shall be provided with grummets and dust seal to exclude dust and dirt. Meshed louvre or ventilation vent with filter shall be provided at both sides for ventilation. All edges shall be rounded. Serrated star washers shall be fitted to ensure satisfactory earthing of the front cover. The switchboard shall undergo de-rusting treatment, anti-rust treatment and be finished with epoxy dry-powder and oven baked semi-gloss beige colour.
The switchboard shall not be mounted directly to the wall structure. It shall be firmly bolted/ welded on to galvanized C-channel brackets which in turn shall be bolted to the wall or structure by means of bolts and nuts. The top of the switchboard shall not be higher than 2100mm and the bottom shall not be lower than 900mm from the floor.

6.7 Associated Components

Busbars shall be of hard drawn high conductivity copper of adequate rectangular cross section to carry continuously the specified current without overheating and also colored in accordance with the latest applicable British Standards.

An earthen busbars of suitable cross section shall be run the full length at the base of the main switchboard.

Connections from busbars to the circuit breakers, switchfuses and fuseswitches shall be effected by means of copper bars or rods securely clamped to the busbars and identified by means of coloured plastic sleeving to indicate the phase colours.

All relays provided shall be heavy-duty pattern, unaffected by external vibration and capable of operation in any position. All meters and relays shall be fully tropicalised.

Earth fault/over current relays with the delay characteristics shall be provided to trip circuit breakers as specified. Earth fault relay shall incorporate drop flag indicator with hand-reset contacts.

All contactors and starters, relays and controllers shall be fitted on insulated panels. All incoming and outgoing circuit and in ring shall be brought to the contactors, starters, relays and controllers, via insulated terminal strips mounted within the metal cubicles, and all wiring between terminal strip and electrical equipment inside the control panel shall be neatly run and taped in accordance with the requirements of the Suruhanjaya Tenaga (ST).

6.7.1 Air Circuit Breakers (ACB)

ACB shall be of withdrawable metalclad, flush mounted, horizontal draw out isolation and air break type suitable for installing on cubicle type of switchboard. They shall be three or four poles type as specified and shall comply fully with IEC 60947-1 and 60947-2. They shall be ASTA or KEMA or other accredited laboratories certified for minimum rupturing capacity, rated short time withstand current, (I_{cw}) of 50 kA at 415 V for 1 second or otherwise specified.

They shall consist of quick-make, quick-break, mechanically and electrically trip free mechanism arranged to give double break in all poles simultaneously. The closing mechanism shall be of stored energy type, either manually or electrically charged. Mechanical `ON' and `OFF' or '|' and '0' indicators shall be provided. The tripping mechanism shall be equipped with push button for independent manual tripping and shall be stable and not being opened by shocks.

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

(a) Service - In this position the main and control contacts are engaged.
(b) Test - In this position the main contacts are isolated but the control contacts are still engaged. It shall be possible to check the correct operation of the control circuits without energising the main circuit.
(c) Isolated - Both main and control contacts are isolated.

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

(a) Prevent withdrawal of breaker while the breaker is in closed position.
(b) Prevent closure of breaker while the carriage is in any position between `fully isolated' and `fully home'.

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

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

Mechanical interlocks and/or electrical interlocks, where specified, shall be provided. Mechanical interlock shall be of code key type, arranged to mechanically operate the trip mechanism latch so that the breaker can only be closed when the key is trapped in the lock. Electrical interlock shall be controlled by means of operation of auxiliary switches of another breaker designed to cut out the closing coils and mechanism of the parent breaker.
Where used as bus-coupler, they shall be of 4 pole type and provided with electrical and/or mechanical interlocks as required so that it is not possible for the coupler to close with its associated main incoming supply breakers closed.

The neutral of the 4 pole type ACB terminals shall be of the same size as the phase. The frame of ACB shall be bonded to the switchboard earthing bar using of 3mm x 25mm tinned copper tape.

6.7.2 Moulded Case Circuit Breakers (MCCB)

MCCB shall comply with MS IEC 60947-2. They shall be fully tropicalised and suitable to be used up to an ambient temperature of 40 ºC, enclosed in glass-reinforced polyester moulded case and suitable for use on 240/415 V, 50 Hz. a.c. supply system.

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

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

(a) Thermal-magnetic types with bimetallic elements for inversetime-delay overload protection and magnetic elements for short circuit protection.
(b) Solid state trip unit with adjustable overload protection and adjustable short circuit protection with or without adjustable time-delay.

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

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

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

If required, the MCCB shall have facilities for shunt trip, under-voltage/no-volt trip, externally connected earth fault protection, externally connected overcurrent protection etc. They shall also have auxiliary contacts, accessories etc. for indication, alarm and interlocking purposes if necessary.

In area where is specified, and door interlocking facilities to prevent the panel door from being opened to access to the MCCB in closed position, shall be provided.

6.7.3 Miniature Circuit Breakers (MCB)

MCB shall be of type approved by Suruhanjaya Tenaga and JKR.

Unless otherwise indicated in the Drawings and/or Schedule of Design Requirements, MCB shall have breaking capacity not less than 6kA (rms) and of C-type with class 3 energy limiting characteristics.

They shall comply with MS IEC 60898-1 and/or MS IEC 60898-2, fully tropicalised and suitable for use on a 240/415 V, 50Hz. a.c. system and up to an ambient temperature of 40°C.

They shall be quick-make, quick-break and trip free type complete with de-ion arc interrupters.

The tripping elements shall be of thermal magnetic type with inverse time delay overcurrent and instantaneous short circuit characteristic. The respond to overload shall be independent of variations in ambient temperature.

They shall be manually operated by means of toggle type handles having visual indication of whether the breaker is opened, closed or tripped.

Multipole MCB shall be of all pole protected type and provided with common-trip mechanism for simultaneous operation of all the poles.

6.7.4 Isolating Switches

Isolating switches or switch-disconnector shall be of metalclad or high impact insulating material (e.g. polycarbonate) type. They shall fully comply with MS IEC 60947-1 and MS IEC 60947-3. The degree of protection shall be IP54 for indoor installation and IP65 for outdoor installation.

They shall be able to operate continuously at full current rating without de-rating, capable of making and breaking currents under normal condition and when in open position, providing isolation from source of electrical energy for reasons of safety.

They shall be quick-make, quick-break type suitable for use on 240/415 V, 50Hz. a.c. system. They shall be provided with removable top and bottom end plates or knockouts for cable entry. The enclosure, the isolating mechanism and all other accessories shall be from the same manufacturer.

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

6.7.5 Contactors

Contactors shall comply with IEC 60947-1 and 60947-4-1. They shall be fully tropicalised, suitable to be used up to an ambient temperature of 40ºC and suitable for use on 230/400V (+10%, -6%)50Hz. A.C. supply system.

The contacts shall be of quick-make and quick-brake type, dust-proof and rust protected. They shall be utilisation category as per Table 12.

Table 12 : IEC Utilization Categories

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

(1) Plugging – Stopping a motor rapidly by reversing the primary power connection.

(2) Inching – Energizing a motor repeatedly for short periods to obtain small incremental movements.

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

6.7.6 Protection Relays

The protection device shall be of the type acceptable to the Supply Authority or Licensee and JKR. The protection relays shall be of panel flush mounting type. All relays shall comply with relevant parts of IEC 60255.

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

Unless specified in the Drawing and/or Schedule of Design Requirements, electromechanical overcurrent and earth fault relay shall be of Inverse Definite Minimum Time (IDMT) type.

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

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

Earth leakage relay (ELR) shall be of the type suitable for use on a 230/400V (+10%, -6%)50Hz. a.c. system and up to ambient temperature of 40ºC ELR shall be provided with test button for simulation of a fault, earth leakage LED indicator a reset button, protection against nuisance tripping due to transient voltage and d.c. sensitive. Unless otherwise specified in the Drawings and/or Schedule of Design Requirements, ELR shall be of adjustable current sensitivity and adjustable time delay type.

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

Unless specified in the Drawings and/or Schedule of Design Requirements, the microprocessor based protection relays shall be rated at 230/400V (+10%, -6%)50Hz and operating voltage shall be in a range from 90V to 250V. The relays shall be housed in robust panel flush mounting case to IP 54 and shall be fully tropicalised and suitable to be used up to an ambient temperature of 50ºC and relative humidity of 95%.

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

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

The microprocessor based protection relays shall incorporate with built-in self-supervision system with auto-diagnosis. The self-supervision system shall continuously monitor the relay microprocessor programs. If a permanent fault is detected, an alarm indication shall be given. A 240V/5A alarm contact for connection to external alarm shall be provided.

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

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

6.8 Measuring Instrument And Accessories

Measuring instrument and accessories shall comply with the relevant IEC Standards. They shall meet the requirement as specified in the Drawings and/or Schedule of Design Requirements.

6.8.1 Measuring Instrument

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

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

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

Kilowatt-hour meter shall be of 6 numbers wheel cyclometer aluminium type with both the current and voltage coils on laminated cover fabricated from high quality silicon steel strip.

They shall have overload capacity of 200% of rated value and accuracy of ± 0.5% at the supply voltage and frequency characteristic. (**For Chiller System Only)**

Power factor meters shall be of balanced type using ferrodynamic, cross-coiled mechanism with measuring range from 0.5 lagging to 0.5 leading. Full scale value accuracy shall be ± 1.5%.
Frequency meters shall be of reed type with frequency range from 45 Hz. to 55Hz. and accuracy of ± 5%.If specified in the Drawings and/or Schedule of Design Requirements, the microprocessor based power meter shall be rated at 240V/415V

and operating voltage shall be in a range from 90V to 265V.

The meters shall be housed in robust panel flush mounting case to IP 54 and shall be fully tropicalised and suitable to be used up to an ambient temperature of 50 0C and relative humidity of 95%.

The meters shall give direct numerical digital readout of actual measured values and recorded values. The meters shall include one serial communication port for external connection to facilitate external reading and recording of meter data and parameters.

The measurements and their accuracy of the microprocessor-based meters shall be:

Table 13: Parameters

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

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

There shall be a custom display screen, which can be programmed to display customised specific parameter requirements.All data shall be continuously and concurrently logged, recorded and stored in internal non-volatile memory (If applicable).

All time base logged-in data can be retrieved and downloaded to a personal computer (PC) using serial communication port (If applicable). PC connecting cable and data retrieving PC program shall be provided (If applicable).

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

6.9 Current Transformers

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

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

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

6.10 Surge Protection Device

The surge protective devices (SPDs) shall be one-port type compatible with the 230/400V (+10%, -6%), 3 phase, 4 wire, 50Hz with solidly earthed neutral supply system it is protecting.

The SPDs shall be of the type complying with MS IEC 61643-1, MS IEC 61643-12 and IEE Std C62.41.2 and in accordance with recommendations of MS IEC 62305 and the relevant parts and section of MS IEC 60364.

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

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

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

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

The maximum continuous operating voltage (U_c) of SPDs shall be minimum 175V for SPDs connected between L-N and (L-E).

When SPDs connected between (N-E), the rating of Uc shall be minimum 240V. The continuous operating current (I_c) for each mode of protection shall not exceed 3mA. In the case where the MOVs are used, the SPDs shall be provided with integrated thermal protection to avoid thermal runaway due to degradation.

The SPDs to be installed with respect to the location of category shall be as in Table 14.

The maximum discharge current (I_{max}) of SPDs shall be declared by the SPD manufacturer by submitting the V-I characteristic of a MOVs / GDT / spark gap.

The SPDs shall be equipped with visual indicator showing the protection status of the SPDs.

Unless otherwise specified, SPDs shall be provided with auxiliary contact for connection to remote monitoring of SPDs protection status.

A durable label with red lettering on a white background with words as stated below shall be fastened externally on the front cover of the SPDs compartment.

AMARAN

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

The size of connecting conductors shall be as recommended by the SPD manufacturer.

The connecting conductors shall be as short as possible (preferably not exceeding 0.5m for the total length) and shall be tightly bound together throughout the whole length with cable-ties or other approved means.

Either a or a fuse of rating as recommended by the SPD manufacturer shall be provided for disconnecting the SPDs from the system in the event of SPDs failure or for maintenance.

In the case where an MCCB is used, the breaking capacity of the MCCB shall comply with the rated ultimate short circuit breaking capacity (I_{cu}) for the switchboards and DB respectively.

The I_{cs} shall be 50% of the I_{cu}.

Table 14: Surge Protecting Devices

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

6.11 System of Wiring

The system of wiring shall be either surface wiring, concealed wiring, surface conduit wiring or concealed conduit wiring as indicated in the Drawings and/or Schedule of Design Requirements. The wiring systems shall comply with MS IEC 60364-5-52.

All wiring shall be run neatly and in an orderly manner. They shall be routed parallel to building wall and column lines in a coordinated manner with other services. The wiring throughout shall be on the 'looping-in system' and no 'tee' or other types of joints are allowed. No reductions of the strands forming the conductors are allowed at all terminals. All strands shall be effectively secured by approved means.

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

All cables shall be legibly marked on the external surface with at least the following elements; Manufacturer's identification, Voltage designation, Nominal area of conductor and Standard Numbers.

Standard colour coded cable shall be used for three phase circuit to identify the phase conductors, neutral conductor and protective conductor respectively.

Opening on floor, wall or partition through which cable, trunking, conduit or other wiring passes through shall be sealed according to the appropriate degree of fire resistance after the installation.

Chipping and cutting of concrete are not allowed unless otherwise approved by the S.O.'s Representative. The Contractor is required to work in conjunction with the building contractor for the provision of openings, trenches, core-holes, chases etc. as the building concreting work progresses.

In steel frame structures, the wiring system shall be rigidly and securely supported and fastened in place onto the structural steel beams, purlins and columns by fasteners such as clamps, clips, anchors, straps, hangers, supports or similar fittings. The fasteners shall be designed and installed as not to damage either to steel structures or wiring system.

The fasteners shall be installed at intervals not exceeding 1000 mm, and within 300 mm of every outlet box, junction box, device box, cabinet or fitting. Fasteners shall be of spring steel and/or galvanized steel, and where wires, rods or threaded rods are used with fasteners, they shall be of rolled carbon steel. The fasteners shall be finished with zinc coatings to resist rusting. Samples for the fasteners used shall be submitted to S.O.'s Representative for approval before they are used.

Unless otherwise approved by S.O.'s Representative, no welding on and/or drilling holes into any members or components of the steel frame structures for the installation of fasteners are allowed.

6.12 Types of Cable

6.12.1 PVC Insulated PVC Sheathed Cable

PVC insulated PVC sheathed cables of300/500 V grade to MS 136 and 600/1000 V grade to MS 274. The conductors shall be of stranded plain annealed copper to MS 69 and MS 280.The insulation shall be suitable for continuous operation at a maximum cable temperature of 70oC and comply with MS 138.

6.12.2 PVC Insulated Cable

PVC insulated cable of 450/750 V grade to MS 136 and 600/1000 V grade to MS 274. The conductors shall be of stranded plain annealed copper to MS 69 and MS 280. The insulation shall be suitable for continuous operation at a maximum cable temperature of 70ºC and comply with MS 138.

6.12.3 XLPE/PVC Cable

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

6.12.4 Armoured Cable

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

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

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

6.12.5 Mineral-Insulated Cables

Mineral-insulated cables shall be manufactured complying with IEC 60702, IEC 60331 and BS 6387 Category C, W and Z for electrical circuit integrity in case of fire. The cables shall have been tested to comply with IEC 60332-1 and 60332-3 for flame retardance, and IEC 61034 for smoke obscuration. The cables shall be halogen free with low organic content and do not release any corrosive emission when subject to fire conforming to IEC 60754-2.

The cables shall be able to withstand a short circuit temperature of 280°C for 5 seconds. For general lighting and power points final circuits, unless otherwise specified, cables of 600V insulation grade may be used.

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

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

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

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

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

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

(a) The cable shall be clipped at the appropriate spacing up to a point adjacent to the equipment and an unsupported anti-vibration loop shall be left in the cable.

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

For mineral-insulated copper sheathed copper conductor (MICC) cables, termination shall be of cold seal type. Silicon rubber sleeve insulation shall be used to replace copper sheath stripped off near the termination for temperature not exceeding 150°C. For temperature exceeding 150°C, varnished glass sleeve insulation shall be used. Insulation and continuity tests shall be carried out before and after the cable is terminated. The insulation test reading shall be 'infinity'. A blow lamp may be used for drying out cable ends.
If it is impracticable to cut to waste, in which event the cable should be brought to cherry red heat at about 600 mm from the end and moisture driven carefully towards the cut end. It is absolutely essential that great care shall be taken to maintain earth continuity when terminating the cables. Dirt and metallic particles in the compound and any loose traces of dielectric left at face of the sheath after stripping shall be removed prior to sealing. Cold sealing compound shall be forced down one side of the pot only until slightly overfilling in order to avoid trapping of air at the base of the pot and to ensure that when the sealing disc is entered before crimping a completely solid insulation barrier is affected.

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

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

6.13 Wiring In Conduit/Trunking (Surface Or Concealed)

The cables used in conduit wiring, unless otherwise specified shall be similar to that described above. Unless otherwise specified in the Drawings and/or Schedule of Design Requirements, the conduits shall be of galvanized steel and conduit fittings shall be of galvanized steel or alloy materials. Cables above false ceiling shall be run in conduit or trunking.

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

Flexible conduit shall be used for termination to equipment, which is subjected to movement or vibration. However, the length of this flexible conduit shall not exceed 400mm unless approved by the S.O.'s representative.

6.14 Metallic Conduits

Steel conduits shall be of galvanized, heavy gauge, screwed type complying with MS 275-1, MS 1534:PT.1, MS 1534:PT.2:Sec1, IEC 60423, IEC 61386-1 and IEC 61386-21. All steel conduit fittings shall comply with MS 275-2, MS 1534:PT.1, MS 1534:PT.2:Sec1, IEC 61035-1, IEC61035-2-1, IEC 61386-1 and IEC 61386-21. The steel conduits shall be fitted with brass bushes at the free ends and expansion devices at appropriate intervals. The ends of each length of steel conduit shall be properly reamed. The termination to the distribution boards, consumer units, switchgears and outlet boxes shall be effected by brass type smooth-bore bushes. All steel conduits shall be effectively earthed.

For laying underground steel conduit shall be used and buried at a minimum depth of 450 mm below ground level or 100 mm below floor slab or hard standing. Junction boxes, outlet boxes etc. shall be of galvanized sheet steel or alloy material or malleable cast iron. The covers shall be galvanized sheet steel or alloy material with thickness not less than 1.2 mm. Accessories such as junction boxes down dropping to luminaries shall have die-cast cone-shaped metal cover.

6.15 Cable Trunking

Cable trunkings shall comply with IEC 61084. They shall be fabricated from galvanized sheet steel and finished with two coats of standard enamel paint. Cable trunkings shall be perforated type for outdoor use to avoid water trap/ponding. They shall be equipped with removable covers at suitable intervals. They shall be supplied in lengths to suit the installation and shall have the following minimum wall thickness:

Table 15: Cable Trunking

NOMINAL SIZE (mm x mm)	MINIMUM WALL THICKNESS (mm)
50 x 50 and below	1.0
75 x 50 to 100 x 100	1.2
150 x 50 to 300 x 150	1.6
Above 300 x 150	2.0

All trunking elbows, offset and combination elbows, adaptors and tees shall be of same thickness as the straight trunking and shall be the type manufactured and supplied by the same trunking manufacturer.

The trunking shall be supported by fixing brackets so that the trunking will not be in contact with the walls or floor slabs. The brackets shall be installed at intervals not greater than 1500 mm for vertical runs and not greater than 1000mm for horizontal runs. The brackets shall be anti-rusted, finished in a primer and coated with standard enamel paint.

Wherever the trunking passes through a floor or a fire resistant wall, fire-resisting barrier shall be provided. At these positions the cables shall be sealed with non-hygroscopic fire resisting material of minimum 2-hour fire rating. In addition, the floor openings and wall openings shall be sealed with similar type of compound.

Cables running in the trunking shall carry conductor identification colours and shall be supported by split hard wood racks securely fixed at the base of the trunking and spaced not more than 600 mm apart.

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

6.16 Cable Trays

Cable trays system shall comply with MS IEC 61537 and shall be fabricated from perforated galvanized sheet steel complete with all necessary bends, tee pieces, adaptors and other accessories.

The minimum thickness of the sheet steel shall be 1.5 mm for cable trays with widths up to and including 300 mm and 2.0 mm for cable trays with width exceeding 300 mm. However minimum thickness for the sheet steel of the perforated hot dipped galvanized cable trays shall be 2.0 mm. Cable trays may either be suspended from floor slabs by hangers or mounted on walls or vertical structure by brackets at 600 mm intervals.

However where the above methods of installation are not feasible or practical, suitable floor mounted mild steel structures shall be provided.

All supports, hangers and structures shall be robust in construction and adequately installed to cater for the weights of the cables and trays supported on them so that cable trays and cables will not sag. All supports, hangers, bracket and structures shall be anti-rusted, finished in primer and coated with standard enamel paint.

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

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

6.17 Cable Ladder

Cable ladder system shall comply with MS IEC 61537 and fabricated from mild steel and finished in hot-dipped galvanized or epoxy powder coat complete with all necessary horizontal elbow, horizontal tee, horizontal cross, reducer straight, outside riser, inside riser, reducer left, reducer right, cable clamp, cantilever arm, hold down clip/clamp, hanger bar, vertical splice plate and horizontal splice plate for welded type and screwed type.

The minimum thickness of the sheet steel shall be 2.0 mm.

Cable ladder may either be suspended from floor slabs by hangers or mounted on walls or vertical structure by cantilever arm.

Cable ladder shall be supported rigidly and adequately by external spring hangers mounted on channel base. The cable ladder shall be supported at maximum intervals of 3000mm for in contact with the wall or floor slab surfaces.

The spring hangers shall be supplied by the cable ladder manufacturer. All supports, hangers, and structures shall be robust in construction and adequately installed to cater for the weights of the cables and ladder supported on them so that cable ladder and cables will not sag.
Rungs shall be spaced at 300mm nominal centres, welded to the rail sections by approved welding procedures. All rungs shall be perforated in accordance to the manufacturer's design.

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

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

6.18 Mounting Heights

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

Table 16: Mounting Heights

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

6.19 Earthing

All motors and equipment earthing shall comply with Electricity Regulations 1994 and relevant parts of MS IEC 60364. All protective conductors, copper tapes and earth electrode shall comply with BS EN 13601.

Installation earthing endorsed by a competent person. All switchboard and earthing shall comply to ELECTRICITY SUPPLY ACT 1990 [ACT 447] P.U.(A) 38/94 ELECTRICITY REGULATIONS 1994 incorporating latest amendments - 431/ 2003.

Any metallic sheath, cover, handle, joint box, switch box, fuse box, switchgear frame, the frame bed plate of any generator, converter, rectifier and motor, the metallic case and core of any transformer, and the metallic frame and cover of any refrigerator, cooking stove and other electrical equipment including any domestic appliance, except those of class II construction, shall be effectively earthed.

Any water pipe connected to a public water supply system shall not be used as a sole means of earthing. Any gas pipe shall not be used as a sole means or earthing.

The neutral point of an alternating current system or the midpoint of a direct current system shall not be connected to earth at more that one point, except with the approval of the Commission. Where the neutral or mid-point of a system is not effectively earthed, an indicative and protective device shall be installed in order to avoid danger due to leakage of current to earth from a live conductor.

Where permission of the Commission has been obtained for the neutral conductor to be used as an earth conductor for earthing the frame of an electrical apparatus, the neutral conductor shall not be used as the return conductor for a single phase supply.

The conductor which is within the natural reach of a person standing on the working platform or in any switchboard passage way shall be placed or protected adequately to prevent danger. The metallic frame of any instrument shall be earthed. The metal handle of a switch and any metal gear for operating the switch shall be earthed.

6.20 Labelling

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

The exact wording of the labels shall be agreed with the S.O.'s Representative. Single line mimic schematic circuit diagram shall be provided at the facial of the switchboards showing the relevant connection. The single line diagram shall be cased in Perspex sheet and riveted on the outside front cover of the switchboard.

6.21 Starters

The starters for each motor shall comply with regulation of ST or Local Authority. Unless otherwise specified or indicated, the Contractor shall provide the following type of starters: -

Table 17: Starters

kW	PHASE	CONSTRUCTION	STARTER
Below 0.75	1	-	Capacitor start induction run
0.75 to 2.25	3	Squirrel Cage	Direct on Line
2.25to 7.5	3	Squirrel Cage	Soft Starter Type
Above 7.5	3	Wound Rotor	Soft Starter Type

All soft starters shall be of reliable brand instead of conventional star-delta or auto-transformer starter and designed only for building services application and the power factor shall remain unity at any condition. Soft starter designed for general purpose shall not be used.

7.0 GENERAL WORKS

7.1 Cleaning, Painting and Identification

7.1.1 General

1. The painting works shall include all equipment, piping, fittings, valves, hangers, conduits, framework, ductwork, insulation, registers, diffusers, grilles, switchboard, machinery etc. and all other works exposed to view.

2. All paints used shall be of approved brand of best quality, low Volatile Organic Compound (VOC) content and ready mixed paint brought to site in unopened containers.

3. No painting shall be done in unsuitable weather. Each coat of painting shall only be applied when the previous coat is completely dry.

4. The Contractor shall provide all tarpaulins, sheets and covering to protect the floors, walls and other works belonging to other trades.

7.1.2 Cleaning

All equipment and piping whether insulated or not shall be thoroughly cleaned and degreased upon completion of his work before any painting is carried out.

7.1.3 Metal Surfaces

All metal works shall be thoroughly wire brushed to remove rust and scale shall be free from grease. The surface shall then be prepared with an approved rust inhibitive primer and two (2) high gloss-finishing coats to approved colors and to the approval of the S.O.

7.1.4 Insulated Surfaces

Exposed insulated surfaces shall first be sealed with an approved pigmented sealer. One (1) coat of undercoat and two (2) coats of approved high gloss paint shall be applied to the surfaces.

7.1.5 Painting of Pipelines

All pipelines shall be painted to approved colors in general to match the surroundings. In addition, lettering and the direction of flow must be indicated by painting a black/white arrow on to the pipelines at appropriate intervals. These arrows shall be 3" long on pipes up to 50 mm (2") diameter, 150 mm (6") long for pipes over 50 mm (2") diameter.

7.1.6 Colors

The following color code shall be employed for the entire installation: -

Housing, ductwork and insulation	*Light Ivory*
Chilled water supply pipes jacketing	*Blue*
Chilled water return pipes jacketing	*Light Blue*
Condenser water supply pipe	*Green*
Condenser water return pipe	Light *Green*
Registers, diffusers and grilles	*to match surroundings*
Pumps	*Jade Green*
Fan housing	*Light Grey*
Electrical conduits	*Orange*
Hangers, supports etc.	*To S.O.'s approval*

7.1.7 Valve Tags

All valves shall be provided with Brass tags, 25 mm (1") min. dia. with stamped identification numbers, secured by chains to each valve handles. Upon completion of the work, a drawing showing the location and purpose of each valve shall be prepared and two (2) copies supplied one (1) under glass in suitable frame, and the other one to the Owner. The drawing shall be complete with all valve numbers and shall enable each piping system to be traced by means of the valve tags.

7.1.8 Name Plates

Supply and install on each of the following, identification nameplates consisting of a lamacoid plastic plate with engraved lettering. The plate size and lettering shall be subject to the approval of the S.O.: -

1 All AHU/FCU, ventilation units and all other exhaust equipment's
2 All starters for AHU/FCU, fans, pumps, compressors, etc.
3 Ducting - Each main duct run shall be identified by reference to system and area(s) served.
4 Controls - All control components including thermometers nameplates shall bear the system number and the identification of the control function.

7.2 Sample of Material for Submission and Approval

The Contractor shall prepare sample board of typical material proposed to use in the work and/or samples of workmanship (mock up) to the approval of the S.O, prior to commencement of the installation work. The sample board and/or samples of workmanship (mock up) shall comprise of but not limited to pipes, pipe fittings, cables, detectors, hanger and support system for ducts, hanger and support system for pipes, duct and pipe insulation, diffuser and grilles and etc.

The cost of the sample board or samples of workmanship (mock up)is deemed to be included in the Contract

