STATE RAILWAY OF THAILAND
MINISTRY OF TRANSPORT

กรุงเทพฯ
Bangkok
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Chachoengsao
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Chon Buri
ระยอง
Rayong

THE HIGH-SPEED RAIL LINKING THREE AIRPORTS PROJECT

REQUEST FOR PROPOSAL

VOLUME 3 : OUTLINE SPECIFICATIONS

VOLUME 3/1 : THE RAIL-RELATED WORKS OF THE PROJECT

PART 2 : OUTLINE CONSTRUCTION SPECIFICATIONS

BOOK 2/2 : BUILDING SERVICES

จีน
China
อินเดีย
India
ประเทศอื่นๆในกลุ่มอาเซียน
Other ASEAN Countries
ประเทศไทย
Thailand

Asian Engineering Consultants Corp., Ltd.
TEAM Consulting Engineering and Management Co., Ltd.
Sasin Graduate Institute of Business Administration of Chulalongkorn University

JUNE 2018

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SECTION 1
BUILDING SERVICE ELECTRICAL WORKS

1.1 GENERAL SPECIFICATION

1.1.1 General

1.1.1.1 Introduction

(1) This general specification and requirement describe the materials and installation of the Electrical works for building services works and related work for the project.

(2) The work shall be executed to completion and in conformity with the detailed design drawings and this specification

1.1.1.2 Operation

Where the Private Party propose to use material and/or equipment which is not specified or detailed on the drawings, the matter shall be brought immediately to the attention of The Engineer's Representative who will make a decision.

1.1.1.3 Environment

(1) The material and equipment shall be installed suitable for tropical climate as mentioned below.

(2) Weather conditions for material and general equipment selection:

(a)	Altitude	:	According to topography of each station location
(b)	Maximum temperature	:	40°C (104°F)
(c)	Average temperature (all year)	:	30°C (86°F)
(d)	Maximum relative humidity	:	85%
(e)	Average relative humidity (all year)	:	60%

1.1.1.4 Standards, Codes and Regulations

(1) The entire system and its basic components shall conform in all respects to the standards and regulations of Electricity Authority. The following standards are mentioned in these Specifications for systems and/or components and, where described, the systems and/or components shall conform to such standards.

(a) ANSI - American National Standard Institute

(b) ASTM - American Society of Testing Materials

(c) BS - British Standard

(d) DIN - Deutsher Industrie Normen (German Industrial Standard)

(e) EIT - The Engineering Institute of Thailand

(f) FM - Factory Mutual

(g) IEC - International Electro Technical Commission

(h) MEA - Metropolitan Electricity Authority

(i) NEC - National Electrical Code

(j) NEMA - National Electrical Manufacturers Association

(k) NFPA - National Fire Protection Association

(l) PEA - Provincial Electricity Authority

(m) TIS - Thai Industrial Standard

(n) UL - Underwriter's Laboratories, Inc.

(o) VDE - Verband Deutsher Electro techniker (German Electrical Regulation and Codes)

(p) Any regulations issued by local authorities.

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

1.1.1.5 Scope of Work

(1) The Electrical System work includes the furnishing of materials, labour, equipment, tools, transportation and services required to construct, install and test the complete electrical system.

(2) It shall be the Private Party responsibility to provide a completely safe and workable system in accordance with the requirements of these Specifications, and the accompanying drawings and schedules all to the entire satisfaction of the Engineer’s Representative.

(3) The Private Party shall coordinate with other trades to ensure that the system and its components furnished form a complete electrical system work with the established construction schedule.

(4) The entire system and its basic components shall conform to the standards and regulation of Electricity Authority standard; EIT 2001-56 standard and

National Electrical Code (NEC). All Standards, codes and regulations shall be the latest issue unless governing authorities require an earlier one.

1.1.1.6 Examination of Drawings and Specifications

(1) The Private Party shall examine all Drawings and Specifications to make sure that all requirements are thoroughly understood. In cases where, in his opinion, there are omissions and/or errors in any of these documents, he shall inform The Engineer’s Representative immediately.

(2) The Private Party shall examine all relevant architectural and structural drawings together with all other utilities systems involved in the Project, prior to installation of machines, materials and equipment.

1.1.1.7 Dimensions

(1) Figured dimensions as indicated on the drawings are to be followed and in no case shall dimensions be scaled from the drawings. Wherever possible, dimensions are to be measured from the building.

(2) Before the Private Party commence any works, he shall ensure that dimensions are checked on the site and/or building and agree with those on the drawings.

(3) The Private Party shall be responsible for the accuracy of such dimensions regardless of the comparable dimensions of the drawings.

1.1.2 Material

1.1.2.1 Material and Equipment

(1) All equipment, materials and parts used shall be new and unused, of current manufacture, of the highest quality and free from defects or imperfections affecting the performance or life of the item and approved by The Engineer’s Representative.

(2) Unless otherwise specifically indicated on the Drawings or in the specification, all materials and equipment shall be installed, with the approval of The Engineer’s Representative, in accordance with recommendations of the manufacturer. However, the approval of The Engineer’s Representative shall not release the Private Party from his responsibility or his liability regarding the properties and workmanship of installations.

(3) The Private Party shall protect all electrical equipment, materials and parts during storage and during construction against the ingress of moisture, contamination or corrosion that might damage the equipment and material.

(4) Certain major equipment defined in the Specifications will be furnished to the Private Party, on site. The Private Party shall assemble, align, level and fix this equipment as instructed by the manufacturer and to The Engineer's Representative's satisfaction.

(5) After the material and equipment have been installed completely in accordance with the instructions, the Private Party shall be responsible for protecting the material and equipment from damages.

1.1.2.2 Equipment Deviations

(1) Where the Private Party proposes to use an item of equipment other than that specified or detailed on the Drawings, requiring any redesign of the structure, partitions, foundations, piping, wiring or any other part of the mechanical, electrical or architectural layout, all such redesign, including drawings and detailing required shall be prepared by the Private Party at his own risk and then approved by The Engineer's Representative.

(2) Where such approved deviation requires a different quantity and arrangement of cable, conduit, and equipment from the specified or indicated on the Drawings, the Private Party shall furnish and install any such cable, conduit, structural supports, insulation, and any other additional equipment required by the system with approval by The Engineer's Representative.

(3) In reference to inspection, all works rejected by The Engineer's Representative shall be repaired, corrected or replaced Private Party to attain good workmanship, and conform to the Contract Drawings and Specifications. Therefore, ample time shall be provided for inspection and, if there is any defective work re-inspection of The Engineer's Representative shall be performed. In the event that the Private Party should fail to carry out necessary changes, then The Engineer's Representative shall have the right to make its own arrangement.

1.1.2.3 Tools and Appliances

(1) Unless otherwise stipulated, the Private Party shall provide any pay for all tools and other facilities necessary for the execution and completion of the works.

(2) If at any time prior to commencement or during the progress of works, tools, equipment and materials, in the opinion of The Engineer's Representative, appear to be insufficient, of inappropriate to secure the required quality of

works or proper rate of progress, The Engineer's Representative may order the Private Party to increase their efficiency, improve their character, augment their number or replace with new tools, equipment and materials as required.

1.1.2.4 Nameplates and Identifications

(1) All parts of the installation, which are of interest for its operation and maintenance, shall be provided with nameplates, tags or arrows, especially in enclosed areas, such as ceiling, shafts, and other places accessible for maintenance service.

1.1.2.5 Submittal of Data for Approval

(1) The Private Party shall submit to The Engineer's Representative complete information regarding details of materials and equipment involved, prior to any purchase or manufacturing operation. Any purchase or manufacturing operations carried out prior to obtaining such approval shall be at the Private Party's sole responsibility.

(2) The equipment information shall be separately submitted by listing all the details and with attached catalogue indicating at least the model, series, size and performance. Such data shall be sufficient detail to enable The Engineer's Representative to identify that particular product and to form an opinion to its conformity to the Specification.

(3) The Private Party shall stamp the name of his company and sign all documents to be submitted for approval.

1.1.2.6 Approval of Materials

(1) Only new materials and equipment shall be incorporated in the Works. All materials and equipment furnished by the Private Party shall be subject to inspections and approval of The Engineer's Representative. The materials and equipment used for Works shall correspond to the approved makes or other data. Any materials which, in the opinion of The Engineer's Representative, have lower quality than the approved makes shall promptly be removed for the job site.

(2) Whenever requested by The Engineer's Representative, the Private Party shall send materials to be tested by an independent institute selected by The Engineer's Representative.

(3) If these should be an unavoidable necessity to use materials and equipment

that deviate from the specification or form approved samples, then the Private Party shall immediately inform The Engineer's Representative in writing and submit the substitute items of equal quality for approval.

1.1.2.7 Detailed Design Drawings

(1) The Private Party shall prepare detailed design drawings in accordance with the SRT's Requirements – Design, comprising complete details of items to be fabricated and works to be installed. These drawings shall be submitted to The Engineer's Representative for approval prior proceeding the preparation of Working Drawings stage.

(2) Detailed design drawings shall be checked and signed by Registered Engineer of the Private Party. All submitted drawings shall indicate the date of submission and the date(s) of revision(s).

(3) All detailed design drawings shall conform to "Outline Design Specification" including design criteria and design calculation. The design criteria and design calculation shall be checked and signed by Registered Engineer's Representative and submitted to The Engineer's Representative for approval.

(4) Size and scale of the detailed design drawings shall be at least 1:100 scale except for enlarged scale details done for clarity, which shall be in conformity with international standards or as directed by The Engineer's Representative.

(5) Where required by The Engineer's Representative, the Private Party shall prepare additional drawings, diagrams, etc., which in the opinion of The Engineer's Representative are considered necessary for a proper execution of the Works.

(6) The approval of The Engineer's Representative never releases the Private Party from his responsibility or his liability regarding the exact dimensions and any further properties of the installations.

1.1.2.8 Working Drawings

(1) After detailed design drawings have been reviewed and approved by Engineer's Representative, the Private Party shall prepare Working Drawings comprising complete details of items to be fabricated and works to be installed. These Working Drawings shall be submitted to The Engineer's Representative for approval before installation.

(2) The drawings shall be checked by the Private Party for accuracy with regard to dimensions taken in the building(s) and shall closely follow manufacturer's recommendations. All submitted drawings shall be signed by the Private Party, and shall indicate the date of submission and the date(s) of revision(s).

(3) In case Working Drawings require modifications for whichever reason, the Private Party has to clearly identify the portion that was modified, and has to indicate the running number of revision every time that a revision-drawing is submitted.

(4) The installation detailed shall be checked with the building works, the structure and other related trades to prevent conflicts that may cause delay of the project.

(5) Size and scale of the Working Drawings shall be at least 1:100 scale except for enlarged scale details done for clarity, which shall be in conformity with international standards or as directed by The Engineer's Representative.

(6) Where required by The Engineer's Representative, the Private Party shall prepare additional drawings, diagrams, etc., which in opinion of The Engineer's Representative are considered necessary for a proper execution of the Works.

(7) The Private Party shall not proceed his work for a certain part or section, prior to the approval of the Working Drawings therefore.(8)Approval of the Working Drawings by The Engineer's Representative shall not be construed as a complete check but will indicate only the general method of installation and its details are satisfactory.

(9) The approval of The Engineer's Representative never releases the Private Party from his responsibility or his liability regarding the exact dimensions and any further properties of the installations.

(10) Working Drawings submitted without sufficient detailed shall be rejected and new submission shall be required.

1.1.2.9 As-Built Drawings

(1) The as-built drawings shall record all changes arising during the installation and detail all relevant data concerning makes types, numbers, capacities, sized and quantities, etc.

(2) The Private Party shall submit to the Engineer's Representative 3 sets of prints and 1 set of reproducible drawings.

(3) The Private Party shall submit to the Engineer's Representative 3 sets of DVD or Portable Hard Disk that contained all PDF documents and AutoCAD files same data as hard copy.

1.1.2.10 Transportation of Materials and Equipment

(1) The Private Party shall submit in advance a transportation schedule of materials to the Engineer's Representative.

(2) The Private Party shall be responsible for all expense incurred during shipping and transporting of material and equipment to the job site. The materials and equipment shall be handled in a manner to prevent warping, twisting, bending, breaking, chipping, rusting and any injury, theft of damage or any kind what so ever.

(3) The shipping documents of particular materials and equipment shall be submitted to The Engineer's Representative as soon as the materials and equipment have arrived at the Site.

1.1.2.11 Materials and Equipment Storage

(1) The Private Party shall prepare storage areas of sufficient size for all necessary materials and equipment brought to the job site. The storage areas shall be provided with access for inspection and removal of the stored materials and equipment.

(2) Materials and equipment delivered to the Site without suitable storage shall not be accepted.

1.1.3 Execution

1.1.3.1 Temporary Power Supply and Others

(1) The Private Party shall connect electrical wires, telephone wires and water pipe for his own use at suitable connection points and shall bear the expense of usage, which shall be removed upon completion of sections of the Works.

1.1.3.2 Responsibility

(1) The Private Party shall establish, maintain, and supervise all precautions and programs for safety and provide protection to prevent damage, injury or loss to:

(a) All workmen on the worksite and other persons who may be affected thereby.

(b) All works and all materials or equipment to be incorporated herein, whether in storage on or off the site.

(2) As the work proceeds, the Private Party shall progressively remove rubbish and surplus materials away from the construction site and shall maintain his working area in a clean and tidy condition as far as is practicable.

(3) Upon completion of the Works he shall, without delay, remove all his temporary works and buildings, all tools, equipment and surplus materials, and shall clean the whole area affected by his work and leave it ready for immediately occupation.

(4) All materials, equipment and finished works shall be kept in good condition. The completed work shall be the Private Party's property until handed over to The Engineer's Representative.

1.1.3.3 Color Coding

(1) For power cables and busbars shall be as follows:

(a) Phase A (R) : Brown

(b) Phase B (S) : Black

(c) Phase C (T) : Gray

(d) Neutral : Light Blue

(e) Ground : Green or Yellow Strip Green

(f) Large wires and cables shall be color coded with tapes as specific color.

(2) For Junction boxes shall be as follows:

SYSTEM	Color Code	Letter
Lighting System	White	L
Emergency Lighting System	Red	LE
Uninterruptible Lighting System	Gray	LU
Receptacle System	White	R
Emergency Receptacle System	Red	RE
Uninterruptible Receptacle System	Gray	RU
Energy Power Billing System	Orange	BS
Building Management System	Brown	BMS
SCADA	Yellow	SD
Structure Cabling System	Blue	SC
IP Telephone System	Green	TEL
Trunk Radio System	Violet	TR
Public Information Display System: (PIDS)	Black	PIDS
Public Address System, (PAS)	Blue Sky	PAS
Central Clock System	Gold	CC
Internet Protocol Television System, (IPTV)	Lavender	IPTV
Controlled Access Security System, (CASS)	Erin	CASS
Closed Circuit Television System, (CCTV)	White/Black	CCTV
Fire Detection and Alarm System, (FDAS)	Red/Yellow	FDAS

1.1.3.4 Field Testing

(1) Test all electrical equipment upon completion of installation to ensure that the equipment operates satisfactorily and to conform to Contract Documents.

(2) Field testing shall be required for all cables and electrical system equipment furnished, installed or connected by the Private Party to assure proper installation, setting, connection, and functioning in accordance with the plans and specifications and manufacturer's recommendations.

(3) Testing shall be conducted in the presence of the Engineer’s Representative and, when necessary, under the supervision of equipment manufacturer's field Engineer’s Representative.

(4) All tests recommended by the equipment manufacturer whether specified in these Specifications or not, shall be included, unless specifically waived by The Engineer’s Representative.

(5) Testing shall include any additional tests issued by The Engineer’s Representative conditions to determine that equipment, material and system meet requirements of the Specifications.

(6) The Private Party shall maintain in triplicate a written record of all tests showing date, personnel making test, equipment or material tested, tests performed and results. Three (3) copies of test records shall be given to The Engineer’s Representative within the following day.

(7) The Private Party shall notify The Engineer’s Representative two weeks prior to commencement of any testing, except for metering.

(8) Private Party shall be responsible for any damage to equipment or material due to improper test procedures or test apparatus handling, and shall replace or restore to original condition any damaged equipment or material.

(9) Safety devices such as rubber gloves and blankets, protective screens and barriers, danger signs, etc. shall be provided by the Private Party and shall be used to adequately protect and warn all personnel in the vicinity of the tests.

(10) The Private Party shall furnish all testing equipment, and furnish temporary power source of proper type for testing purposes when normal supply is not available at the time of testing.

(11) Conduit and wiring system shall be checked to ensure that the system has been installed in such a way as to provide a safe and reliable system.

(12) Lighting system shall be checked at night to ensure that illumination levels as specified have been met.

(13) All interlocks, control and alarm circuits shall be given an operation test (If any).

(14) The insulation test of each conductor shall not be lower than the accepted level as required by Authority concerned.

(15) The grounding system resistance shall not be more than 5 ohms.

(16) Test all miscellaneous equipment furnished by equipment manufacturer as recommended by the manufacturer i.e., circuit breaker, low voltage switchboard, motor (if any) etc unless specifically waived by The Engineer's Representative.

(17) Include all additional tests issued by Engineer's Representative that he deems necessary because of field conditions, to determine that equipment and material and systems meet requirements of these Specifications.

1.1.3.5 Operation and Maintenance Instructions Manual

(1) The manual shall be prepared in hard cover building in sets to be submitted to The Engineer's Representative on acceptance of the completed work.

(a) Section 1 Comprises submittal data of all equipment and materials that have been approved.

(b) Section 2 Comprises catalogues, categorized in groups, complete with installation operations and the maintenance manuals from the manufacturers.

(c) Section 3 Comprises filled out test reports in the field.

(d) Section 4 Comprises spare parts list and recommended spare parts.

(e) Section 5 Comprises maintenance and services schedule, and service and maintenance procedures for individual equipment listed daily, weekly, monthly, quarterly and yearly.

(f) Section 6 Comprises system operation manuals.

(2) A draft copy of the manual shall be submitted to The Engineer's Representative for approval first.

1.1.3.6 Works to Completion

(1) The Private Party shall commission, clean down, and leave in full working order the works as specified.

(2) As the installation proceeds, the Private Party shall prepare record drawings of

the Electrical system installation, as-built drawings. It will be sufficient to modify these contract drawings showing any amendments to the service which have taken place and submit the marked-up prints to The Engineer's Representative for approval.

(3) The Private Party shall deliver to The Engineer's Representative on completion of the works, manufacturer's literature, specifications, technical information and record drawings for all equipment installed.

1.2 EMERGENCY POWER GENERATOR SET

1.2.1 General

1.2.1.1 General Requirement

(1) The emergency generator set (standby type) shall include, but not be limited to, the following:

(a) Complete diesel engine generator set, including radiator, anti-vibration mountings and holding down bolts.

(b) Exhaust system including all silencers, suspension and thermal insulation.

(c) Complete fuel system including a daily service tank, all pipes, valves and feed pump where required.

(d) Control panel complete with all accessories and controls to provide a complete and operable system.

(e) DC electric starting system.

(2) The generator set shall have provision for both manual and fully automatic starting and be capable of transferring the designed connected load in the event of a complete mains failure or a deviation outside the acceptable limits and to do so in not more than 15 seconds.

(3) The generator set shall be adequately sized to meet the load requirements under worst case considerations according to the load schedule produced at the detailed design stage. Details of the sizing shall be submitted for approval.

(4) Sound attenuation material shall be provided and installed in the generator room and at the generator; to suppress the noise came out for not exceeding 80 dBA @ 1 meter around the room.

1.2.1.2 Standard and Reference

(1) IEC 60034-1 : Rotating electrical machines - Part 1: Rating and performance

(2) BS ISO 3046-1 : Reciprocating internal combustion engines – Performance – Part 1: Declarations of power, fuel and lubricating oil consumptions, and test methods – Additional requirements for engines for general use

(3) BS ISO 3046-4 : Reciprocating internal combustion engines – Performance – Speed governing

(4) NEMA 250 : Enclosures for Electrical Equipment (1000 Volts Maximum)

(5) NEMA MG 1 : Motors and Generators

(6) NFPA 30 : Flammable and Combustion Liquids Code

(7) NFPA 37 : Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines

(8) NFPA 70 : National Electric Code

(9) NFPA 99 : Health Care Facilities Code

(10) EIT 2001-56 : Thai Electrical Code 2013

(11) Local Ordinances, Rules, Regulations covering installation, material inspection and testing.

(12) Emission value of diesel engine: in accordance with TA Luft or EURO-II standard.

1.2.1.3 Submittals

(1) Product Data

(a) Submit product data indicating unit ratings, dimensions and finishes.

(b) Submit full detail spec sheet and engineering data including engine, alternator, controller and related accessories.

(c) Submit statement of compliance. Any deviation from the basic requirement shall be considered only when it renders more superiority in performance.

(d) Submit operation requirement and maintenance data including instructions for normal operation, routine maintenance requirements for engine, alternator and controller.

(2) Working Drawings

(a) Submit Working Drawings showing electrical diagrams including schematic and interconnection diagrams.

(b) Submit manufacturer’s installation instructions and Working Drawings showing the installation method of the generator set and accessories.

1.2.1.4 Quality Assurance

(1) Qualifications

(a) Manufacturer: Company specializing in packaged engine generator system with minimum of ten (10) years documented experience and shall be latest ISO 9001 certified.

(b) Supplier: Authorized distributor of generator shall be responsible for providing all equipment, service facilities and spare parts.

(2) Particular Requirement

(a) The manufacture of various components and accessories shall be as recommended by the generator manufacturer to ensure compatibility.

(b) The diesel generator set shall be imported as a complete assembly from the manufacturer.

(c) The manufacturer shall have proven experience of the installation and commissioning of generator set in Thailand.

(d) Notwithstanding any description or detail (implied or otherwise) included hereafter, the final installation shall comply with all the necessary Statutory Requirements and any other relevant regulations to enable the installation to be operative.

(3) Warranty

All parts of the generator set and its accessories shall be guaranteed by the manufacturer and/or the Private Party at least two (2) years after handover.

1.2.1.5 Delivery, storage and Handling

(1) Deliver generator set and accessories to site in crates. The materials shall be inspected on site and verified damage.

(2) Store and protect products from dirt and moisture by securely wrapping in heavy duty plastic.

1.2.1.6 Maintenance

(1) Extra Materials

(a) Furnish one (1) set of tools required for preventive maintenance of the engine generator system. Package tools in adequately sized metal tool box.

(b) Provide two (2) additional sets of each fuel, oil and air filter element required for the engine generator system.

(2) Maintenance Service

(a) Furnish service and maintenance of packaged engine generator system from Date of Substantial Completion for the warranty period stated.

(b) Submit a complete list of spare parts, which includes part numbers, drawing number and part descriptions.

(c) Submit a list of the genuine spare parts recommended by the manufacturer to be replaced during five (5) years of services with current unit prices.

1.2.2 Materials

1.2.2.1 Description

(1) General

Each generator set shall consist of engine, radiator, alternator and controller, mounted on a steel base. The generator set shall be factory assembled and aligned accurately on the steel base, which shall be strong and rigid enough to ensure permanent alignment of all rotating units and prevent vibration build up and shall permit skidding in any direction during installation.

(2) General Characteristics:

(a)	Number of sets required	:	as per the design at the detailed design stage.
(b)	Rated power output	:	as per the design at the detailed design stage.
(c)	Power factor	:	0.80 lagging
(d)	Speed	:	1500 rpm
(e)	Frequency	:	50 Hz.
(f)	Rated Voltage	:	400/230 V, 3 phase, 4 wire
(g)	Type of excitation	:	Brushless with permanent magnet pilot exciter.
(h)	Load acceptance	:	Capable to accept 100% load acceptance of nameplate rating in a single step from an initial startup condition.

(3) Voltage Regulation

The voltage regulation from no load to full load shall not exceed ± 0.50% of rated voltage. The steady state voltage variation shall be less than ± 0.50% of rated voltage.

(4) Frequency Regulation

As defined by engine governor performance.

(5) Total Harmonic Content

The line voltage waveform shall have total harmonic content not exceeding 5% of the fundamental under all operating conditions.

(6) Motor starting capacity shall equivalent to between 160% and 250% of full load kVA.

(7) The completed generator set shall meet or exceed the following performance criteria:

(a) Voltage regulation shall be ± 0.5 percent rated voltage.

(b) Steady state voltage stability ± 0.5 percent rated voltage.

(c) Balanced telephone interference factor (TIF) shall not exceed 50.

(d) Frequency regulation from no load to full load shall be isochronous operation.

(e) Generator set shall be capable of start-up and accepting rated load within 10 seconds.

1.2.2.2 Engine

(1) Type

Engine shall be industrial generator drive diesel engine for stationary applications. The engine shall be the standard product of the manufacturer, a current production model complete with all auxiliaries normally furnished and shall provide sufficient power to drive the coupled alternator. The engine shall be compression ignition type, water-cooled turbo-charged with or without intercooler, 4 stroke cycle, direct injection high pressure type fuel injection system, multi cylinder, V-type with removable cylinder liner, designed for industrial use.

(2) Governor

The engine speed shall be governed by an electronic governor to maintain governed speed at precise isochronous operation. The governor shall provide adjustable speed setting to permit automatic parallel operation and load share control with other generator set. The frequency at any constant load including no load shall remain within a steady state band width of ± 0.25% of rated frequency. Application and removal of rated load shall allow in transient frequency change not exceeding 10% and recover to 3% change within 8 seconds. Other performance deviated from above specified values shall be accepted for consideration only when it renders to the best benefit to the SRT.

(3) Turbocharger

Turbocharger shall be of the turbine type driven by exhaust gas from the engine cylinders and direct-connected to a blower that supplies air to the engine intake manifolds. The turbocharger shall be pressure – lubricated. All necessary supports and connections shall be provided.

(4) Intercoolers

For cooling the intake air from turbochargers shall be of the tubular heat exchanger type. All necessary intercooling equipment including valves, controls and integral piping shall be provided.

(5) Vibration Limitation

The engine generator set shall be equipped with vibration absorber to be free of damaging flexural vibrations and dangerous torsional critical speed.

(6) Fuel System

The system shall consist of a day tank and engine fuel pump.

(a) Fillpoint : Shall be wall mounted type consist of 50 mm. (2 inches) pipe and valve and shall be installed where the oil truck is accessible.

(b) Day Tank: Shall be mounted on non-combustible support near the engine to provide and immediate fuel supply to the engine fuel pump and shall be situated so that the fuel level in the day tank above the engine injection pump. A flexible suction line to the engine, an excess fuel return line from the engine to the day tank, a vent and a drain pipe shall be completely provided Capacity is to supply engine at rated power not less than 12 hours.

c) Engine Fuel Pump: Shall be a positive displacement, engine driven pump capable of supplying and adequate quantity of fuel to the engine under all operational conditions. Solenoid shut-off valve in fuel discharge line shall be interlocked emergency shutdown circuitry.

d) Level Monitoring day tank shall be monitored by level monitoring system and, if indicated, interface to BAS system.

(7) Lubrication

The engine shall be provided with a complete lubricating oil system, pressurized by an engine-driven oil pump. A relief valve for oil pressure regulation and a gauge or dip-stick for oil level indication shall be furnished.

(a) Filtering: Full flow oil filters with replaceable element including a spring loaded by-pass valve to ensure oil circulation, if filters are clogged, conveniently located for servicing, shall be provided.

(b) Oil Cooling: An oil cooler, if necessary shall be incorporated within the lubricating system.

(8) Engine Cooling System

The system shall be water cooled, pressurized system having sufficient capacity for cooling the engine during engine operation at full load at ambient temperature 40 degrees C.

(a) Radiator Cooling: An engine – mounted radiator or separated radiator with an engine driven pusher fan or electrical motor fan capable of maintaining a 13.44 degrees C temperature differential between inlet and outlet water. The driving belt shall be enclosed in fan cowling and hand protection guard.

(b) Raw-Water Circulating Pump: Shall be and engine driven centrifugal pump with an automatic controlled by-pass valve to maintain the engine at recommended temperature level and to assist rapid heat up after starting maneuver.

(c) Provide remote radiator if ventilation can’t suffice for cooling (provide if indicated).

(9) Air–Intake System

(a) Air Filter: The engine air-intake opening shall be equipped with an effective, easily cleaned air filter which is capable of removing all material down to 100 micron. The filter unit shall be easily removable to allow replacement of filter element.

(b) Silencer: For suppression of high frequency sounds which as capable of reducing the sound level at the air intake to a point that is acceptable for residential use.

(10) Exhaust System

The system shall complete with separate system for each engine and shall include a flexible section, a muffler and exhaust piping graded away from the engine to the outside.

(a) Flexible exhaust section: Shall consist of convoluted seamless tube without joints or packing and be capable for absorbing vibration from the engine and thermal expansion and contraction of exhaust piping.

(b) Exhaust muffler: Shall be of the chamber type, constructed of welded steel. Each muffler shall be provided with eyebolts, lugs, flanges, or other items necessary for mounting. Pressure drop through the muffler shall not exceed the recommendations of the engine manufacturer. Outside mufflers shall be zinc coated.

(c) Exhaust Silencer Critical Type: Shall reduce the exhaust sound spectrum between low frequency band (20-75 Hz) and high frequency band (4800-10 kHz) to below 37-40 dB, used full engine load.

(d) Exhaust System Installation: The exhaust piping shall be securely supported, prevent rain entering the outlet pipe and shall incorporate a condenser trap and drain valve in exhaust piping. All parts of the exhaust system shall be insulated with sufficient non-flammable insulation covering to prevent heat dissipation and burns from accidental contact.

(11) Starting System

The engine shall be equipped with an electric starting system which is arranged for fully automatic starting upon the failure of any phase of the main power supply.

(a) Battery: The storage battery shall be a lead acid, sealed – in plastic for maintenance free type complete with battery rack and inter-cell connectors. The battery shall be of sufficient capacity, at ambient temperature of 40 degrees C. to provide at least 4 cranking periods of 15 seconds each, with 15 seconds rest between cranks.

(b) Battery Charger: A current-limiting battery charger shall be furnished to automatically recharge the batteries. The charger shall be capable of a high charge rate for recharging fully depleted batteries within 8 hours, and a low charge rate for maintaining the batteries in prime starting condition. An ammeter shall be provided to indicate charging rate.

(c) Exerciser: An automatic plant exerciser timer shall be provided to permit periodic operation of the standby generator set.

(12) Piping and Fittings

Pipe anchors, pipe sleeves, plates, flashing and flexible pipe connectors shall be provided for pipe installation.

(13) Safety System

(a) Shutdown controls: The engine shall be equipped with automatic safety controls, switches and circuitry which shutdown the engine and open the generator circuit breaker immediately, in the event of low lubricating oil pressure, high jacket – water temperature, engine over-speed and engine under-speed.

(b) Alarm System: The safety system shall incorporate visual-audio alarm signals that become operational before engine shutdown and corresponding device activates.

(c) Time Delay Device: Shall be installed in automatic cranking panel for automatic start-stop operation of generator set. The time delay relay shall be-pass the low oil-pressure shutdown switch during cranking and return oil-pressure switch to the circuit after engine starts.

(14) Flywheel

The flywheel shall be statically and dynamically balanced and capable of being rotated at 125 percent of rated speed without damage.

(15) Engine Instrumentation

The engine instrument panel which is attached to the engine by vibration absorbing type mountings shall contain the following items for proper engine surveillance and maintenance:

(a) Cooling water temperature gauge

(b) Lubricating oil pressure gauge

(c) Running time meter

(d) Tachometer

(e) Emergency stop switch

(f) Key switch for manual start

(g) Automatic shutdown alarm

1.2.2.3 Alternator

(1) Construction

The alternator shall be directly coupled to the engine flywheel through a flexible driving disc for positive alignment. The alternator housing shall be bolted directly to the engine flywheel housing and shall have single or double bearing, prepacked with lubricant, support for the rotor which shall be statically and dynamically balanced. Food mounting and lifting points shall be arranged around the center of gravity. The alternator shall be protected and enclosed in drip-proof casing with balanced cooling fan.

(2) Excitation

The field excitation shall be performed by a rotating three phase AC exciter and a brushless rotating silicon diode rectifier with surge protector assemble mounted on the rotor shaft. Constant output voltage control shall be achieved transistorized automatic voltage regulator which adjusts the exciter field current to compensate for all variations. The voltage regulator shall maintain the voltage within the limits of plus or minus 0.50 percent from no load to full load.

(3) Insulation

The alternator shall be suitably treated for operation under tropical climate. All windings shall be impregnated with epoxy resin of thermosetting insulation vanish to establish class H insulation.

(4) Voltage Regulator

Shall be of static solid state type three phase with silicon diode control. A device for manual adjustment of regulated voltage shall be provided and shall extend a range of 10 percent rated voltage under all operating conditions. A manual / automatic switch shall permit selection of manual and automatic control of voltage.

(5) Overload Capability

A compound circuit incorporated in the system shall ensure addition excitation during motor starting duties and fault condition.

(6) Parallel Operation (if specified on the detailed design stage)

Fully inter-connected pole face damping windings shall be incorporated to ensure smooth operation. An automatic load sharing device shall be provided for quadrate current compounding in conjunction with the specified electronic governor to enable generator set to run satisfactorily in parallel with utility.

(7) Non-Linear Load

The Alternator shall be furnished together with special control system to enable the set to deliver the output power for the non-linear land up to 60% of rated output without effecting to its performance.

(8) Radio and Telephone Interference

An appropriated radio, telephone frequency interference and line disturbance suppression circuits shall be provided.

(9) Exciter field power shall be provided separate to the brushless exciter. Provide sufficient power to the excitations system to produce 250% short circuit from the main operator armature during a three phase fault with sufficient duration for protective devices to operate.

1.2.2.4 Generator Control Panel

Generator control panel shall be provided which incorporates complete control for all functions of the set. The control panel shall be programmable microprocessor logic controller with alphanumerical display, alarm and remote communication with BAS system. The control panel shall contain the necessary equipment and measuring instrument such as:

(1) AC voltmeter with phase selector switch

(2) AC ammeter with phase selector switch

(3) Frequency meter

(4) Automatic voltage regulator control

(5) Kilowatt meter

(6) Power factor meter

(7) Kilowatt-hour meter

(8) Main circuit breaker

(9) Signal Lamp for operation and alarm

(10) Other necessary components

1.2.2.5 Alarm System

Visual and audible alarm shall be completely provided and connected to BAS system.

1.2.2.6 Assemble

The generator set, control panel shall be assembled and tested at the manufacturer’s factory and shall have a certain product range and own type, model number and code.

1.2.3 Execution

1.2.3.1 Examination

(1) Verify that surfaces are ready to receive work and field dimensions are as shown on the approved Working Drawings.

(2) Verify that required utilities are available in proper location and ready for use.

(3) Beginning of installation means installer accepts existing conditions.

1.2.3.2 Installation

(1) The Private Party shall install the Emergency Generator Set and its accessories in accordance with the approved Working Drawings and manufacturer's instructions, and in compliance with the requirement of the NFPA as stipulated; EIT 2001-56; and the recommendation of PEA.

(2) The Generator Set shall be installed on the concrete base 150 mm. heights.

(3) All equipment shall be installed as recommended and certified by the manufacturers.

1.2.3.3 Field Quality Control

(1) Field inspection and testing will be performed after completion of the Works according to NEMA MGI.

(2) Provide full load test utilizing without interruption portable test bank, if required, for four hours minimum. Simulate power failure including operation of transfer switch, automatic starting cycle and automatic shutdown, and return to normal.

(3) During test, record the following at 20 minute intervals:

(a) Kilowatts

(b) Amperes

(c) Voltage

(d) Coolant temperature

(e) Room temperature

(f) Frequency

(g) Oil pressure

(4) Test alarm and shutdown circuits by simulating conditions.

(5) Private Party Field Services

(a) Prepare, start, test and adjust systems until the systems are ready to operate.

(b) Any defects found during this test shall be corrected by the Private Party.

1.2.3.4 Adjusting

(1) Adjust work as necessary.

(2) Adjust generator output voltage and engine speed to rated value.

1.2.3.5 Cleaning

(1) Clean work thoroughly.

(2) Clean engine and generator surfaces. Replace oil and fuel filters after test procedure.

1.2.3.6 Demonstration

(1) Provide system demonstration and describe loads connected to emergency system and restrictions for future load additions.

(2) Simulate power outage by interrupting normal source and demonstrate that system operates to provide emergency power.

1.3 LOW VOLTAGE SWITCHBOARD AND CAPACITOR BANK

1.3.1 General

1.3.1.1 General Requirement

(1) The Low Voltage Switchboard and Capacitor Bank in this Section comprise the following major equipment:

(a) Main Distribution Boards

(b) Sub-main Distribution Boards (for both non-essential and essential loads)

(c) Distribution Boards (for both non-essential and essential loads)

(d) Capacitor Bank (Power Factor Correction equipment)

(2) The Low Voltage Switchboard and Capacitor Bank, in scope of Building Services electrical work, shall be applied for Stations and Depot only. The Private Party shall furnish and install such equipment and associated accessories as specified hereafter and as indicated on the approved drawings at the detailed design stage.

(3) The Low Voltage Switchboard and Capacitor Bank shall be capable of being fully operated under the environmental conditions without any derating factors.

(4) The switchboard assemblies, manufactured in Thailand, shall be designed and fabricated follow the licensed Type-Tested low-voltage switchgear and controlgear Assemblies (TTA) in accordance with IEC 61439-1 and IEC 61439-2 and complete with License or Verified Assemblies certificates.

1.3.1.2 Standard and Reference

The Low Voltage Switchboard and Capacitor Bank and their accessories shall comply with the following codes and standards.

(1)	IEC 61439-1	:	Low-voltage switchgear and controlgear assemblies - Part 1: General rules
(2)	IEC 61439-2	:	Low-voltage switchgear and controlgear assemblies - Part 2: Power switchgear and controlgear assemblies
(3)	IEC 60947-1	:	Low-voltage switchgear and controlgear - Part 1: General rules
(4)	IEC 60947-2	:	Low-voltage switchgear and controlgear - Part 2: Circuit-breakers
(5)	IEC 60947-4-1	:	Low-voltage switchgear and controlgear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters
(6)	IEC 60947-7	:	Low-voltage switchgear and controlgear - Part 7: Ancillary equipment
(7)	IEC 60269-1	:	Low-voltage fuses - Part 1: General requirements
(8)	IEC 60269-2	:	Low-voltage fuses - Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) - Examples of standardized systems of fuses A to K
(9)	IEC 60269-4	:	Low-voltage fuses - Part 4: Supplementary requirements for fuse-links for the protection of semiconductor devices
(10)	IEC 61869-1	:	Instrument transformers - Part 1: General requirements
(11)	IEC 61869-2	:	Instrument transformers - Part 2: Additional requirements for current transformers
(12)	IEC 61326	:	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements
(13)	IEC 61010-1	:	Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements
(14)	IEC 62053-21	:	Electricity metering equipment (a.c.) - Particular requirements - Part 21: Static meters for active energy (classes 1 and 2)
(15)	IEC 61921	:	Power capacitors - Low-voltage power factor correction banks

(16) IEC 60831-1 : Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1000 V - Part 1: General - Performance, testing and rating - Safety requirements - Guide for installation and operation

(17) IEC 60831-2 : Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1000 V - Part 2: Ageing test, self-healing test and destruction test

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

(19) IEC 61643-11 : Low-voltage surge protective devices - Part 11: Surge protective devices connected to low-voltage power systems - Requirements and test methods

(20) NFPA 70 : National Electrical Code

(21) EIT 2001-56 : Thai Electrical Code 2013

In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

1.3.1.3 Submittals

(1) The Private Party shall submit the certificates, technical data, Working Drawings, material lists, wiring diagrams and installation instructions to the Engineer's Representative for approval prior to proceed purchasing order.

(2) The Private Party shall submit the TTA certificates of the equipment to the Engineer's Representative for approval prior to proceed purchasing order. The License or Verified Assemblies certificates shall be issued by an international independent third-party testing authority/institute (such as ASTA, LPCB, KEMA, TÜV or other institutes according to the Engineer's Representative deem appropriate). The Certificates shall be clearly indicated about the recent valid date-month-year of approval, standard of assemblies and condition of product. Each certificate shall be complete with successfully verified 12 design requirements separated into two main parts; 'construction' and 'performance' as stipulated in the following table below:

No.	Characteristics to be verified	IEC 61439-1 & 2 Clauses or Sub-clauses	Verification options available		
			Verification by testing	Verification by calculation	Verification by design rules
	Verification of construction				
1	Strength of material and parts including:	10.2			
	– Resistance to corrosion	10.2.2	YES	NO	NO
	– Thermal stability	10.2.3.1	YES	NO	NO
	– Resistance of insulating materials to normal heat	10.2.3.2	YES	NO	NO
	– Resistance to abnormal heat and fire due to internal electric effects	10.2.3.3	YES	NO	NO
	– Resistance to ultra-violet (UV) radiation	10.2.4	YES	NO	NO
	– Lifting	10.2.5	YES	NO	NO
	– Mechanical impact	10.2.6	YES	NO	NO
	– Marking	10.2.7	YES	NO	NO
2	Degree of protection of enclosures	10.3	YES	NO	YES
3	Clearances and creepage distances	10.4	YES	YES	YES
4	Protection against electric shock and integrity of protective circuits including:	10.5			
	– Effective continuity between the exposed conductive parts of the ASSEMBLY and the protective circuit	10.5.2	YES	NO	NO
	– Effectiveness of the assembly for external faults	10.5.3	YES	YES	YES
5	Incorporation of switching devices and components	10.6	NO	NO	YES
6	Internal electrical circuits and connections	10.7	NO	NO	YES
7	Terminals for external conductors	10.8	NO	NO	YES
	Verification of performance				
8	Dielectric properties including:	10.9			
	– Power-frequency withstand voltage	10.9.2	YES	NO	NO
	– Impulse withstand voltage	10.9.3	YES	NO	YES

No.	Characteristics to be verified	IEC 61439-1 & 2 Clauses or Sub-clauses	Verification options available		
			Verification by testing	Verification by calculation	Verification by design rules
9	Temperature-rise limits	10.10	YES	YES	YES
10	Short-circuit withstand strength	10.11	YES	YES	YES
11	Electromagnetic compatibility (EMC)	10.12	YES	NO	YES
12	Mechanical operation	10.13	YES	NO	NO

(3) The Private Party shall submit the installation details and location plans of the switchboard for approval prior to proceed installation.

(4) The Private Party shall submit short-circuit coordination patterns along the protective lines of the Main/Sub-main Distribution Boards to the Engineer's Representative for approval prior to energize power.

1.3.1.4 Quality Assurance

(1) The equipment manufacturer shall be latest ISO 9001 certified.

(2) All parts of the equipment including its performance shall be guaranteed by the manufacturer and/or the Private Party for at least two years after handover.

1.3.2 Materials

1.3.2.1 Description

(1) The Low Voltage Switchboard shall have the electrical characteristic as follows:

(a) System Wiring : 3-phase, 4-wires solidly ground

(b) Rated Voltage : 400-Y/230V

(c) System Voltage : 380-Y/220V

(d) Rated Frequency : 50 Hz.

(e) Insulation Class : 600V (Minimum)

(f) Rated Continuous Current : as per the design at the detailed design stage.

(g) Rated Short Circuit Current : as per the design at the detailed design stage.

(h) Degree of protection : IP 31 (For Indoor use)

(2) All circuit breakers in the Switchboards shall be of the same manufacturer and in accordance with the TTA certificate. The circuit breakers shall comply with the IEC standards and Main CB in Main Distribution Boards (MDB) shall be equipped with Ground Fault protection.

(3) An under-voltage sensing relay shall be installed on the secondary side of each transformer to sense loss of voltage and it has an adjustable time delay feature so that if the supply voltage drop to zero, it must remain at that value for a period of 3 second before tripping the Main incoming circuit breakers and Non-essential main circuit breakers.

(4) Spare circuit breakers with aggregate three phase current rating not less than 25% of the main bus bar current rating shall be provided. Spare panel space on top of the 25% spare circuit breaker capacity shall be provided for future expansion.

(5) All cable terminations and component circuit references shall be properly labeled & tagged.

1.3.2.2 Main / Sub-main Distribution Boards

(1) Panel Construction

(a) The Switchboards shall be of vermin proof with ventilation louvers, indoor purpose, free-standing, front accessible, and should be fabricated in modularized design system, fully extensible, self-supporting on steel frame construction in 2 mm thick (minimum or in accordance with the TTA) and enclosures fabricated of not less than 2 mm of nominal thickness galvanized steel sheet and shall have a door on the front in which operating mechanism are mounted.

(b) The Switchboards shall be completely self-supporting structure of the require number of vertical sections bolted together to form a single metal switchboard can be easily separated from another and each vertical section shall be sized range of 600-1,200mm wide, 400-1,200m deep and 2,000-2,200mm high.

(c) Metal barriers shall divide the switchgear unit into compartments to provide separated totally 3 basic compartments from front to rear in form 3b as follow:

(i) Circuit breaker compartment for installation of switchgear equipment.

(ii) Busbars Compartment is the chamber for busbar installation both horizontal and vertical.

(iii) Cable compartment which be provided for power cable incoming and outgoing from the switchboard.

Each compartment, as mentioned above, shall have sheet metal safety partition with minimum thickness not less than 2mm.

(d) The top, sides and rear cover plates shall be removable and attached to the frame with rustproof screws. The front doors shall be attached the frame with the hidden hinged and approved keys providing easy opening to the doors.

(e) All front plate use for mounting meters, selector switches or other front mounted devices shall be hinged with all wiring installed and laced with flexibility at the hinged side. The back closure plate shall also be hinged type and other closure plates shall be screw removable and small enough for easy handling by one man.

(f) Busbar supports shall be formed of high-dielectric strength and low moisture absorption molded compound with the high impact strength and low creepage surface.

(g) All current carrying parts shall be copper.

(h) All steel parts of the panel shall be completely dry and chemically clean, prevent corrosion, before being painted with the non-rusting primer and not less than two stoved enamel-coatings finished on top both inside and outside. Finish shall be light grey with RAL standard color, unless otherwise directed by The Engineer’s Representative.

(i) Ventilating louvers where required shall be provided on the sides and backs of panels and shall be of approved design. All louvers shall be screened.

(j) Mimic diagram shall be plastic strip adhered on the front of the panel showing single line diagram of the system. Mimic bus shall be 3 mm. thick and 10 mm. widths.

(k) The flexible braided ground strap (tinned copper) with standard size shall connect all removable doors to the frame.

(l) All of the feeder cubicles shall be designed for feeder cables enter from the top. Removable cover plates for all cable entrances shall be provided.

(m) Suitable supports for cables and wiring shall be provided within the cubicles to prevent undue stresses on terminal connections.

(n) The switchboards shall be provided with adequate lifting means, and be capable of being rolled or moved into position and bolted directly to the floor without the use of floor sills.

(2) Busbars and Supports

(a) The Main Busbar shall be arranged throughout the switchboard in the sequence of R-S-T from left to right, top to bottom and front to back as viewed from the front and to permit future additions. Busbars shall be bare copper and permanently labeled by phase for identification of each phase, neutral and protective conductor as following:

(i) Phase R (or A) of three-phase ac. Circuit with Brown colored

(ii) Phase S (or B) of three-phase ac. Circuit with Black colored

(iii) Phase T (or C) of three-phase ac. Circuit with Gray colored

(iv) Neutral of three-phase ac. Circuit with Light blue colored

(v) Earthing conductors with Green or Green-with-Yellow strip colored

(b) The main Busbar shall have a continuous current rating not less than the main breaker, and the individual unit buses shall have a current rating not less than of the feeders. Buses shall be braced and supported for the maximum allowable fault current of the incoming breakers.

(c) The Busbars shall be 98% copper and shall be mechanically braced to withstand the maximum symmetrical short-circuit current rating of the main breaker in each assembly. The busbars shall have sufficient cross sectional area to continuously conduct rated full load current, as shown on the approved single line diagram, for operation in 35^{o}C ambient temperature and for limit temperature rise within the requirements of IEC 61439-2. The current carrying capacity of busbar shall be of the bare busbar rating, conformed to IEC 61439-2.

(d) Neutral busbar shall be furnished through the entire length of the switchgear and it shall be connected to the transformer neutral. All switchgear equipment requiring neutral shall be connected to this bus. Bolted type terminal lugs shall be furnished for connecting the neutral bus to the incoming and outgoing cables.

(e) A ground busbar, 33% size of phase bus, shall be furnished to the entire length of the switchboard. All switchgear equipment requiring grounding shall be connected to this bus.

(f) All bolted bus jointed shall be silver plated or tin plated, and all joints shall be securely tightened to Manufacturer's standards for each size of hardware. Bolted, Nut and Washer for buses connection shall be high tension class and the contact point between buses and terminal pad shall be electrical compound painted.

(g) Busbar holders shall be of fiber-glass reinforced polyester (FRP) type or Epoxy-resin (flame-proof material) or better. The calculation sheets and technical data, showing the minimum spacing between the busbar holders for withstand the maximum force caused by short circuit current, shall be submitted for approval. The horizontal main busbar supports, connections, and joints shall be bolted to be free of required periodic maintenance.

(3) Circuit Breakers

(a) All circuit breakers installed in switchboards shall comply with IEC 60947-1, IEC 60947-2 standard.

(b) All circuit breakers shall be selected to perform in coordination pattern along the protective lines.

(c) Terminals of all circuit breakers rating ≤ 250 AF shall be cable lugs and the others shall be busbar terminals.

(d) Air Circuit Breaker (ACB)

The Air Circuit Breakers (if applied) shall have the following characteristic:

(i)	Number of poles	:	to be specified on the detailed design stage
(ii)	Rated current (AT)	:	to be specified on the detailed design stage
(iii)	Icu	:	to be specified on the detailed design stage
(iv)	Ics	:	100% of Icu
(v)	Short circuit withstand	:	Icu at 1 Sec

(vi) Fixed type or Draw-out type as specified on drawing.

(vii) Spring charging can be operated by either manual or motorized.

(viii) 2-steps operating mechanism:

Step 1 Charge closing spring (can be operated by either manual or motorized).

Step 2 After the spring is fully charged, press button at the front of circuit breaker to close the circuit breaker contacts.

(ix) The draw-out mechanism shall be hold the breaker rigidly in the CONNECTED, TEST, and DISCONNECTED position (for draw-out type). Interlocks shall be provided which will prevent connecting the breaker to, or removing it from; the bus stabs unless the breaker is OPEN (tripped). All spare contacts on breaker position switches and auxiliary relays shall be wired to accessible terminal blocks. Each breaker shall be provided with 4 N.O and 4 N.C auxiliary contacts for Buyer’s use.

(x) Each Air circuit breaker shall have an independent manual “CLOSE” push button and a “TRIP” push button with stored energy or spring assisted mechanism, and shall be provided with “CLOSED” , “OPEN” indicator whether the mechanism is fully “charged” and “discharged” indicator shall be provided.

(xi) Geared motor for automatic charging of closing spring shall be provided. The motor charges the closing springs again immediately after the circuit breaker has closed.

(xii) The closing springs can, however, be charged manually (using the relative operating mechanism lever) in the event of a power supply failure or during maintenance work.

(xiii) Control contacts shall make when the breaker is in the “CONNECTED” position and break when in the “DISCONNECTED” position. The auxiliary contacts shall make when the breaker is in the “CONNECTED” position and break when in the “TEST” and “DISCONNECTED” position.

(xiv) The circuit breaker shall be completed with accessories or devices as listed below:

1) Auxiliary Switches

2) Time Delay Under-voltage Trip

3) Shunt Trip

4) Motor Operate

5) Alarm Switch

6) Microprocessor adjustable Trip Unit (True RMS sense) as followings:

a) Long time protection (LT) can be adjusted from 0.4–1 time of ampere rated current (In) and can be adjusted time delay from 15–480 seconds at 1.5 time of ampere rated.

b) Short time protection (ST) can be adjusted from 1.5–10 time of ampere rated current (In)

c) Short time delay / Long time delay

d) Instantaneous trip (INST)

e) Thermal Memory up to 20 minutes (before and after tripping)

f) Ground fault protection, current pick-up adjustment and time delay type

g) LCD display for current value, trip history, type of fault, pre-trip alarm and main contact maintenance shall be built-in the circuit breaker.

h) Healthy unit LED for self-inspection

i) Communication feature can be added on future demand.

(e) Molded Case Circuit Breaker (MCCB)

The MCCB shall have the following characteristic:

(i) All Molded case circuit breakers shall be 3-pole, rated 415 Vac, 50 Hz and shall be manual operated, trip free from the handle and provided with fixed or adjustable thermal overload and instantaneous magnetic short-circuit protective elements. The MCCB ampere frame rating ≤ 250 AF shall be thermal magnetic trip type and others shall be electronic trip type.

(ii) Quick–make, quick–break and trip-free for over-current and short circuit current, and have a common trip on all multi-pole breakers with internal tie mechanism.

(iii) Drives shall be toggle operating mechanism, operated by trip-free system and shall have clearly indication whether the circuit breaker is "ON", "OFF" or "TRIP". All breakers shall be provided with terminal connectors for connecting to the outgoing feeders.

(iv) De-rating factors shall be considered where applicable to compensate for ambient temperature, enclosure, loading duty cycle, frequency and altitude.

(v) All MCCB shall be capable of being installed the additional devices such as shunt trip, under-voltage relay, auxiliary switch, alarm switch, rotary handle, pad locking device, etc to increase performance of the protection control.

(vi) Trip unit for the MCCB rating ≤ 250 AF shall be thermal-magnetic trip with adjustable thermal current from 0.7–1.0 time of rated Ampere-Frame (AF).

(vii) Trip unit for the MCCB rating ≥ 400 AF shall have rating plug to adjust ampere rating. The ampere rating can be adjusted from 0.1–1.0 time of rating plug for overload current, and 3-10 times of rating plug for short circuit current.

(viii) All circuit breakers rating ≥ 1000 AT shall be completed with ground fault sensor. The sensor shall have the following characteristic:

1) Ground-fault clearing time of main circuit breaker shall be more than the clearing time of feeder circuit breaker.

2) Ground fault pick-up current ≥ 200 A. (adjustable)

3) Time delay can be set at 0.1, 0.2, 0.3 and 0.4 Sec

(4) Measuring Devices and Instruments

(a) *Multifunctional Digital Power Meter (DPM)*

(i) The DPM shall be panel mounted type, complete with LCD or LED display unit. The display unit shall have the minimum 3 rows with 7 characters per row for value monitoring.

(ii) The DPM shall be in compliance with IEC 61326, IEC 61010-1 and IEC 62053-21 standard or other approved equivalent.

(iii) The DPM shall be able to measure true RMS values as follows (minimum):

1) Current : per phase

2) Voltage : V_{L-L} and V_{L-N}

3) Power : kW, kVAR, kVA per phase and total at 3 phases

4) Power Factor : per phase / average at 3 phases

5) Frequency : incoming electrical source (Hz.)

6) Energy : kWh, kVARh, kVAh (Class 0.5)

7) Harmonic : THDi and harmonic order from 3^{rd} Up to 15^{th}

(iv) The DPM shall be completed with built-in RS-485, Mod bus communication port or RS-422 communication ports (2 ports) to interface with Building Management System (BMS) and/or SCADA System.

(v) The DPM shall be operated at rated voltage not exceed 600 V_{L-L} and current rating ≤ 5 A (from secondary of current transformer).

(vi) The accuracy of power meter shall be as follows:

1) Current / Voltage : 0.5 %

2) Power / Energy : 0.5 %

3) Power Factor : 0.5 %

(b) Analog Meters

(i) Each indicating instruments shall be semi-flush mounted, back connected, dustproof, fully tropicalized, switchboard type with a dull black case for mounting on a steel panel. Each shall be suitable for operation with the instrument transformers specified on the detailed design stage.

(ii) Except as otherwise specified, all indicating instruments shall be approximately 96mm x 96mm square with a 90°C scale arc. All ammeters and voltmeters shall be of the moving iron type. The maximum error of each indicating instrument shall not be more than 1% of full scale range.

(iii) The scale ranges of ammeters, voltmeters, watt-meters and var-meters shall be chosen so that, under normal operating conditions, each instrument will read between 70-80% of the effective scale range. Scale plates shall have a permanent white finish with black graduations and numerals.

(iv) The ammeters for which the upper limited of the effective range does not exceed 20 amps may be direct (series) connected. For higher range, current transformer operated ammeter shall be used, and shall be designed for a secondary current of 5 amps.

(v) Accuracy Class of the meters shall be 1.0 or better.

(vi) Voltmeters shall be the direct connection type with the accuracy class 1.0 (or better) and scale range 0-500V.

(c) Instrument Transformers

(i) The current transformers shall be suitable for use with meters, and shall be tropical proof type with a 5A secondary and a primary rating equal to continuous current rating of circuit breaker. All current transformers shall have thermal and mechanical limits coordinated with the short-time rating of the circuit breakers with which they are used.

(ii) All current transformer secondary leads shall be brought out to shorting type terminal blocks located in the instrument compartments and shall be arranged to provide any combination of connections or polarity.

(iii) The current transformer shall not be used in dual-purpose role serving both instrument and protective device.

(iv) Accuracy Class of the current transformers shall be in accordance with the following function:

1) Tariff metering : 0.5
2) Non-tariff metering : 1.0
3) Switchboard indicating instrument : 1.0
4) Protection : 10P

(v) The voltage transformer (if applied) shall be of the air-insulated type, with the windings encapsulated in epoxy resin or other suitable synthetic material. All voltage transformer secondary leads shall be brought out and connected, through secondary fuses, to terminal blocks for external connections or connection to other devices integral to the switchgear. These fuses and terminal blocks shall be mounted in the instrument compartments.

(d) Other Instruments and Accessories

(i) On 3-phase, 4-wire systems, Ammeter Switches (if applied) shall have four operating positions, marked 'R', 'S', 'T' (or ‘A’, ‘B’, ‘C’), 'N', and 'OFF' position, and shall enable the single ammeter to read, in sequence, the currents in each of the three phases and the neutral wire. Ammeter switches shall have 'make-before-break' contacts and shall be connected so that the associated current transformers are short-circuit when they are not connected to the ammeter.

(ii) On 3-phase, 4-wire systems, Voltmeter Switches (if applied) shall have seven operating positions, marked 'R-S', 'S-T', 'T-R', 'R-N', 'S-N', 'T-N', and 'OFF' position, and shall enable the single voltmeter to read, in sequence, each of the three line voltages and each of the three phase-to-neutral voltages. Voltmeter switches shall have 'break-before-make' contacts.

(iii) All indicating and pilot lamp assemblies shall be of the low power, cool operating, 24 V, switchboard type, with color caps and integrally mounted resistors. The color caps shall be Red, Yellow, and Blue. The lamp bulbs shall be replaceable from the front of the panels.

(iv) Undervoltage relay shall be provided to turn off the main circuit breaker when the voltage falls below premeditated level. Undervoltage relay shall be 3-phase, 4-wire, 400/230V, 50Hz unit. The undervoltage setting shall be adjustable to 10% with time delay setting 0-10s. The undervoltage relay shall include phase sequence and phase failure to trip the breaker when one phase falls symmetrically.

(5) Surge Protection Equipment

(a) General

(i) The surge protection equipment shall comply with IEC 61643-11 or VDE 0675-6-11 standard.

(ii) The installation of the equipment shall be fully 4 poles connection ($L_{R(A)}$ – Ground, $L_{S(B)}$ – Ground, $L_{T(C)}$ – Ground and Neutral – Ground).

(b) Lightning Current Arrester (LCA)

The LCA, installed in Main Distribution Boards, shall be as Shunt Surge Protection to capture and discharge lightning current, and shall have the following characteristic:

(i)	Reference standard	:	IEC 61643-11 Class I or approved equivalent
(ii)	Nominal Voltage; U_N	:	≥ 240 V, 50 Hz
(iii)	Nominal discharge current; I_n (8/20 μs)	:	≥ 25 kA (L – PE)
(iv)	Impulse discharge current; I_{imp} (10/350 μs)	:	≥ 50 kA
(v)	Follow current interrupt rating; I_{fi}	:	≥ 50 kA_{rms}
(vi)	Voltage protection level; U_p	:	≤ 1.5 kV
(vii)	Response time; t_A	:	≤ 100 ns
(viii)	Ambient temperature range	:	-40^{O}C to 80^{O}C
(ix)	Degree of protection	:	IP 20

(c) Surge Voltage Arrester (SVA)

The SVA, ***if applied***, shall be modular plug-in type made from Metal Oxide Varistor to capture the rest of voltage surge from low voltage feeder. The arrester shall be completed with status indicator (“Normal”, “Fault”, “Defect”, etc.) and self-disconnection, and shall have the following characteristic:

(i)	Reference standard	:	IEC 61643-11 Class II or approved equivalent
(ii)	Nominal voltage; U_N	:	≥ 240 V, 50 Hz
(iii)	Maximum continuous operating voltage; U_C	:	≥ 275 V, 50 Hz
(iv)	Nominal discharge current; I_n (8/20 μs)	:	≥ 12.5 kA (L – PE)
(v)	Maximum discharge current; I_{max} (8/20 μs)	:	≥ 25 kA (L – PE)
(vi)	Voltage protection level; U_p	:	≤ 1.5 kV
(vii)	Response time; t_A	:	≤ 25 ns

(viii) Ambient temperature range : -40^{O}C to 80^{O}C

(ix) Degree of protection : IP 20

(6) Control wiring and terminal blocks

(a) All control wiring shall be with flexible, stranded copper conductors, switchboard wire rated not less than 600V / 90^{o}C, and shall not be less than 1.5 mm^2 except for current transformer circuits which shall not be less than 2.5 mm^2. All hinged wiring shall be extra flexible. The wiring shall be neatly and carefully installed in suitable wiring ducts with removable covers and shall be terminated at suitable terminal blocks. Splices shall not be permitted in control wiring or instrument leads.

(b) The switchgear shall be provided with terminal blocks for termination of all wiring devices and each terminal block shall be clearly identified to show wiring which will be installed by the Private Party. Extra terminals, in a quantity of not less than 25% of the active terminals, shall be provided on each terminal block for circuit modifications and for future use. The terminal blocks shall be located so that the accessibility to them will not be lessened by interference from structural members or panel instruments. Ample space shall be provided at terminal blocks for termination of external circuits.

(c) Terminal block shall be spring type, screwless, maintenance-free connection, rail-mounted type. No current carrying metal shall be exposed after cables or terminal blocks accessories are connected.

(d) Terminal blocks for final connections for indication, instrumentation and metering circuitry shall have test probe facilities for connections of test leads and an integral disconnecting device to facilitate testing. Terminal blocks utilized in the secondary circuits of current transformers and electrical measuring transducers shall be of short-circuiting elements type.

(e) Wiring shall be identified at each end with a legible printed black marking sleeve. Sleeves shall be white tubing, sized to fit the insulation. Sleeves shall be able to rotate on the wire so not to inadvertently hide the wire number.

(f) Nameplates shall be furnished and mounted by the Private Party. Each assembly, each piece of equipment mounted on an assembly, and each power and control circuit shall be provided with a nameplate. All nameplates shall be made of laminate plastic. Characters shall be black on a white background.

(g) All indicating and pilot lamp assemblies shall be of the low power, cool operating, 24V, switchboard type, with color caps and integrally mounted resistors. The color caps shall be Red, Yellow, and Blue. The lamp bulbs shall be replaceable from the front of the panels.

1.3.2.3 Distribution Boards

(1) General

(a) The distribution boards shall serve the distribution of electrical power to machinery/motors, socket outlets, lighting system, etc. The load shall be connected either directly to these boards or via sub-distribution boards.

(b) The distribution boards shall be of metal-enclosed indoor, factory-built type. A minimum protection of enclosure IP31 shall be provided. Distribution boards of 100A and above shall be provided with voltmeter and ammeter complete with selector switches as indicated. All distribution boards shall be provided with incoming and outgoing LED indication lights.

(c) Each distribution board shall be provided with 25% load spare breakers. The overall rating, incoming cable and upstream provision shall be such that a 25% load increase for future expansion can be accommodated without alternation to the distribution system.

(2) Panel Construction

(a) The distribution board enclosure shall be made of electro-galvanized steel sheet (minimum thickness 2 mm) and finished with epoxy-powder coating (minimum 60 micron) colored to The Engineer's Representative's acceptance. The enclosure shall be completed with hinged doors and to be provided with standardized key lock and 3 sets of keys shall be provided for each distribution board. All DB doors shall be provided with separate latches in addition to the door locks.

(b) The distribution boards shall be supplied fully equipped, wired, and proofed against vermin, dust and moisture, designed for free-standing or for wall-mounting, and cable access from beneath or above. Proper warning signs indicating danger and voltage level shall be provided.

(c) Unless otherwise accepted, access to the boards shall be from the front, the doors shall be furnished with lift-off hinges to permit an opening enabling an unrestricted access to the board interior. All doors and covers shall be fitted with moulded gaskets of non-ageing material.

(d) The distribution boards shall be provided with 3-phase tinned copper conductor busbars rated for continuous current and short circuit current. The busbars shall be designed to withstand dynamic forces due to peak short circuit current. All busbars including droppers and termination to the circuit breakers shall be color-coded as the same color as busbars in Main LV Switchboard.

(e) Each distribution board shall also be equipped with neutral busbar having the same rating as the phase-buses, and Earth busbar rating as 33% of the phase-buses.

(f) As-built single line diagram, control circuit and layout plan shall be inserted in a permanent pocket on the inner side of the panel door of each distribution board.

(3) Circuit Breakers (CB)

Refer to clause 1.3.2.2 (3) (e).

(4) Measuring Devices and Instruments

(a) Multifunctional digital power meters, if applied, shall refer to the specification as described in Clause 1.3.2.2 (4) (a).

(b) Analog Meters, if applied, shall refer to the specification as described in Clause 1.3.2.2 (4) (b).

(c) Instrument Transformers, if applied, shall refer to the specification as described in Clause 1.3.2.2 (4) (c).

(d) Other instruments and accessories shall refer to the specification as described in Clause 1.3.2.2 (4) (d) for one or more items are applied in the design.

(5) Internal cabling

(a) All internal cabling in each item of equipment shall be installed in cabling channels or conduits. Exposed cabling shall be kept to a minimum but where necessary, the wires shall be formed into compact groups suitably bound together and properly supported.

(b) All conductors shall be terminated with suitable pressure type terminal lugs of proper sizes for terminal studs at the terminal blocks or shall be terminated in a manner compatible to the terminals of the instruments.

(c) All conductors shall run continuously between terminal studs without splices or taps and all conductors shall be labeled at each termination with wire number as designated on the circuit diagrams.

(d) All internal cabling shall be insulated stranded copper wire, rated at not less than 600V / 90^{o}C. And minimum cross-sectional area shall be;

(i) 1.5 mm^2 for control circuits

(ii) 2.5 mm^2 for voltage and current circuits

1.3.2.4 Power Factor Correction equipment

(1) General

(a) Power factor correction equipment shall comprise capacitor units, control relay, switching equipment, protective fuses and means of isolation, all assembled and connected to control automatically the connection and disconnection of the capacitance in response to change in the load power factor.

(b) The Capacitor bank shall be connected to main Busbar of the Main Distribution Boards as means of power-factor-correction equipment which provides the reactive power directly at the loads, it is possible to stabilize the system voltage and reduce the transmission losses.

(c) Power factor correction equipment shall carry out the power factor improvement to PF = 0.95 lagging or better. Provision shall be made to ensure that a connection point is available for series connected, detuning reactor in case of problems with high harmonics. The Private Party shall submit the calculation report for approval.

(d) The application of capacitor units shall be automatically operated via contactors. This process shall be controlled by multi-stage, kVAR sensitive, solid state relay which cycles the capacitor stages so that each is called into service in sequence and advances so that each capacitor is used equally.

(e) Permanently connected discharge resistors shall be provided across the termination sized to ensure safe discharge of the capacitors to less than 50 V within 1 minute after disconnection. The capacitors shall be capable of operating for prolonged periods, without damage, at an applied voltage up to 110% of the rated voltage.

(f) The capacitor banks shall be designed so that alteration or addition of the capacitor in the future will not affect the system.

(g) The capacitor bank shall be installed in separate cubicle from Low Voltage Switchboard which is the same design as the main switchboard and as the manufacturer recommendation. The cubicle shall be IP31 protection class and naturally ventilated.

(h) Auto/Manual selector switch shall be provided and installed on front of the cubicle. In manual mode, On-Off push button switch shall be provided for manual switching with indicator lamp.

(i) All Indicator lamps shall be LED type with current limiter block.

(2) Component

The power factor correction equipment shall be at least equipped with the required following:

(a) Capacitor Bank Unit

(i)	Type	:	Self-healing type for a.c. systems, indoor use, dry technology, metallization polypropylene film.
(ii)	Standards	:	IEC 60831-1 & 2 or UL 810
(iii)	Casing	:	Aluminium or better material
(iv)	Rated voltage	:	3-Phase, 440 V.ac.
(v)	Rated frequency	:	50 Hz.
(vi)	Rated power	:	to be specified on the detailed design stage.
(vii)	Target Power factor setting	:	0.95 lag – 0.99 lag
(viii)	Self-protection	:	Internal fuse within each element and over pressure disconnector
(ix)	Losses	:	≤ 0.5 W/kVAR (include discharge resistors)
(x)	Tolerance	:	-5% ... +10%
(xi)	Protection	:	IP 20
(xii)	Overcurrent / duration	:	1.30 x In / permanent
(xiii)	Overvoltage / duration	:	1.1 x Un / 8 hours - 24 hours
(xiv)	Peak inrush current	:	≤ 200 x In
(xv)	Ambient temperature	:	-10°C ... +40°C

(b) Reactive Power Factor Controller

(i) Type : Solid state, microprocessor continuous digital power factor display, permanent setting, insensitive harmonics

(ii) Rated voltage : 3-Phase, 4-wires, 400/230V

(iii) Rated frequency : 50 Hz.

(iv) Number of step control : to be specified on the detailed design stage.

(v) Protection : IP 41

(vi) LCD or LED display that can provide information of the following parameters (minimum):

1) Power factor (actual and target)

2) Current (A)

3) Voltage (V)

4) Reactive power (kVAr) (actual and target)

5) Frequency (Hz)

6) Harmonic Voltage (3^{rd} … 13^{th} harmonic order at minimum)

7) Harmonic Current (3^{rd} … 13^{th} harmonic order at minimum)

8) Temperature

(vii) Control features (minimum):

1) Control power factor in the system due to load variation.

2) Capacitor switching can be set as manual or automatic switching.

3) When temperature inside the cubicle reaches the setting temperature, the controller should operate the ventilation fan.

4) Alarm output in case of high temperature, high harmonics current and power supply missing.

(viii) Password protection.

(c) Magnetic Contactors

(i)	Type	:	Capacitor switching type, utilization category AC-6b, heavy duty type (life more than 200,000 operations)
(ii)	Standard	:	IEC 60947-4-1
(iii)	Number of pole	:	3 poles
(iv)	Control voltage	:	220-240 V.ac
(v)	Rated insulation voltage	:	≥ 1,000 V.
(vi)	Peak inrush current	:	≥ 100 times of Capacitor current
(vii)	Rated thermal current	:	≥ 1.43 times of Capacitor current

(d) HRC Fuse Link and Fuse Base

(i)	Type	:	Current limiting HRC fuse
(ii)	Standard	:	IEC 60269-1 & 2
(iii)	Rated voltage	:	≥ 500 V.ac
(iv)	Rated current	:	≥ 1.6 times of capacitor current
(v)	Rated breaking capacity	:	120 kA at 500 V.ac
(vi)	Ambient temperature & humidity	:	+45 ^{O}C, 95% RH or higher
(vii)	Fuse base	:	Triple-poles with phase barriers for rated current > 250 A.

1.3.3 Execution

1.3.3.1 Installation

(1) The Private Party shall install the Low Voltage Switchboard and Capacitor Bank in accordance with the approved Working Drawings and manufacturer's instructions, and in compliance with the requirement of NFPA 70; EIT 2001-56; and the recommendation of PEA.

(2) The floor-standing type of all LV switchboards and Capacitor Banks shall be installed on the concrete plinth 150 mm. heights.

(3) All equipment shall be installed as recommended and certified by the manufacturers.

1.3.3.2 Field Testing

(1) Field inspection and testing for Switchboards shall occur after installation is complete, feeders are terminated, and the room is secure. Testing shall be conducted not more than 4 weeks before equipment is energized.

(2) Testing scope:

(a) Visual and physical inspection of equipment.

(b) Check control wiring and metering.

(c) Meter calibration

(d) Ground fault protection.

(e) Insulation testing for equipment.

(f) Adjust circuit breaker setting based on recommendations in the short circuit and co-ordination study.

(g) Primary current injection testing of circuit breakers.

(h) System grounding.

(i) Function and operation testing for equipment inclusive interlocking scheme.

(3) Certified test report:

(a) Verify that the installation is in accordance with Standards and regulations.

(b) Verify that the equipment has been fully tested and is operational.

1.3.3.3 Factory Testing

(1) The routine testing, for Switchboards at factory, shall comply with IEC 61439-2 and covers below lists:

(a) Wiring and Operation testing

(b) Protective measures

(c) Insulation resistance.

1.4 LOAD CENTER, SAFETY SWITCH AND ENCLOSED CIRCUIT BREAKER

1.4.1 General

1.4.1.1 General Requirement

(1) The Private Party shall furnish and install the load centers, safety switches and enclosed circuit breaker and their accessories as specified hereafter and as indicated on the approved drawings at the detailed design stage.

(2) The load centers shall be sized to meet the load schedules produced at the detailed design stage.

1.4.1.2 Standard and Reference

The equipment and its accessories shall comply with the following codes and standards.

(1)	IEC 61439-3	:	Low-voltage switchgear and controlgear assemblies - Part 3: Distribution boards intended to be operated by ordinary persons (DBO)
(2)	IEC 60947-1	:	Low-voltage switchgear and controlgear - Part 1: General rules
(3)	IEC 60947-2	:	Low-voltage switchgear and controlgear - Part 2: Circuit-breakers
(4)	IEC 60947-3	:	Low-voltage switchgear and controlgear - Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units
(5)	IEC 60898-1	:	Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations - Part 1: Circuit-breakers for a.c. operation
(6)	IEC 61009	:	Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs)
(7)	IEC 60529	:	Degree of protection provided by enclosures (IP Code)
(8)	NEMA KS 1	:	Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum)
(9)	NFPA 70	:	National Electrical Code
(10)	EIT 2001-56	:	Thai Electrical Code 2013

1.4.1.3 Submittals

(1) The Private Party shall submit material lists and technical data for approval prior to proceed purchasing order.

(2) The Private Party shall submit the installation method and details for approval before installation.

1.4.1.4 Quality Assurance

(1) The equipment manufacturer shall be latest ISO 9001 certified.

(2) All parts of the equipment including its accessories shall be guaranteed by the manufacturer and/or the Private Party at least two years after handover.

1.4.2 Materials

1.4.2.1 Description

(1) All equipment shall have the electrical characteristic as follows:

(a)	System Wiring	:	3-phases, 4-wires with ground or 1-phase, 2-wires with ground as specified on the detailed design stage.
(b)	Rated Voltage	:	400Y/230V
(c)	System Voltage	:	380Y/220V
(d)	Rated Frequency	:	50 Hz.
(e)	Rated Continuous Current	:	as per the design at the detailed design stage
(f)	Rated Short Circuit Current	:	as per the design at the detailed design stage (at 415 or 240 V.)

1.4.2.2 Component

(1) Load Center

(a) The load centers shall be of dead-front safety surface mounted type, fitted with hinged front door and shall enclose all miniature and main circuit breaker suitably shrouded for safe working conditions.

(2) Miniature circuit breakers which are equipped with the load centers shall be of frame, trip rating and interrupting capacity (including blank spaces for future addition) as shown in the load schedules. The circuit breakers shall be quick-make, quick-break, thermal-magnetic, trip-indicating conforming to IEC 60898-1 and have a common trip on all multi-pole breakers with internal tie mechanism.

(3) Main circuit breakers for the load center (if applied) shall comply with IEC 60947-1, IEC 60947-2 standard and shall have electrical characteristic as specified on the detailed design.

(4) Bus bar connections to the branch circuit breaker shall be in the “phase-sequence” type.

(5) On the inside of the door of each cabinet, a typewritten directory shall be provided which will indicate the location of the equipment or outlets supplied by each circuit. The directory shall be mounted in a metal frame with a non-breakable transparent cover. The load centers designation shall be typed on the directory card and the panel designation stenciled in 40 mm. high letters on the inside of the door.

(6) Auxiliary switches for remote monitoring ON/OFF/TRIP status for SCADA Interfacing shall be provided for emergency lighting circuits.

(7) Residual Current Circuit Breaker (RCCB) or Residual Circuit Breaker Operator (RCBO’s) shall be provided for protect all socket outlet circuits with rated at 30mA sensitivity according to IEC 61009 standard. The RCCB/RCBO’s shall not trip out on loss of supply voltage and shall have the appropriate short-circuit strength for the location in the system at which they are installed and shall be capable of making, carrying and breaking the full short-circuit current..

(2) Safety Switch

(a) The safety switches shall be either Fused Safety Switches or Non-Fused Safety Switches as required on the approved detailed design.

(b) The switches shall be heavy duty type equipped with switch blades, a quick-make and quick-break operating handle and mechanism which shall be an integral part of the box. Service door of each safety switch shall be interlocked so that it cannot be opened while the switch is in "ON" position.

(c) Current rating of the switches shall be as approved at the detailed design stage.

(d) All fuses for "fused safety switch" shall be of the high rupturing capacity (HRC) type of voltage rating up to 600 volts. Current rating shall be suitable for equipment loading.

(e) The switches shall be IP 31/NEMA 12 general purpose enclosure with knockouts unless otherwise noted or required. Switches (sealed) located outdoor or in wet areas shall have IP 54/NEMA 3 enclosures.

(3) Enclosed Circuit Breaker

(a) Enclosed circuit breakers shall be molded-case circuit breakers assembled in enclosed steel box which have electrical characteristic as indicated on the drawings.

(b) Enclosed circuit breakers shall be IP 31/NEMA 12 general purpose enclosure with knockouts unless otherwise required. The (sealed) enclosed circuit breakers which are located on outdoor area or in wet area shall be IP 54/NEMA 3 enclosure.

(c) The circuit breakers shall comply with IEC 60947-1, IEC 60947-2 standard.

1.4.3 Execution

1.4.3.1 Installation

(1) The equipment shall be installed in accordance with the approved Working Drawings and manufacturer's instructions, and in compliance with the requirement of NFPA 70; EIT 2001-56; and the recommendation of PEA.

(2) The Private Party shall supply, adapt and install a steel work at the top and/or the bottom the equipment to permit where necessary the incoming or outgoing of the cables, conduits, and wires.

(3) Load Centers shall be mounted rigidly with expansion bolts on concrete or nuts and bolts on wooden or metal wall at a height of 1,800 mm. above the finished floor to top of the Load Centers.

(4) Provide filler plates (steel type) for unused spaces in Load Centers.

1.5 AUTOMATIC TRANSFER SWITCH

1.5.1 General

1.5.1.1 General Requirement

(1) The Private Party shall furnish and install the automatic transfer switches (ATS) and its accessories as specified hereafter and as indicated on the approved drawings at the detailed design stage.

1.5.1.2 Standard and Reference

The automatic transfer switches shall comply with the following codes and standards:

(1) IEC 60947-6-1 : Low Voltage Switch and Control gear: Multifunction equipment, Automatic Transfer Switching equipment

(2) UL 1008 : Transfer Switch Equipment

(3) NFPA 110 : Standard for Emergency and Standby Power Systems

(4) NFPA 70 : National Electrical Code

1.5.1.3 Submittals

(1) The Private Party shall submit Working Drawings, wiring diagrams, material lists and technical data for approval prior to proceed purchasing order.

(2) The Private Party shall submit the test certificates and test reports complying with IEC 60947-6-1 and/or UL 1008 issued by an international independent third-party testing authority/institute (or the institutes according to the Engineer's Representative deem appropriate).

1.5.1.4 Quality Assurance

(1) The equipment manufacturer shall be latest ISO 9001 certified.

(2) All parts of the equipment including its performance shall be guaranteed by the manufacturer and/or the Private Party for at least two years after handover.

1.5.2 Materials

1.5.2.1 Description

(1) The automatic transfer switches shall be designed and manufactured accordance to the IEC60947-6-1. Design utilizing components of molded case circuit breakers, contactors, or part thereof which are not be intended for continuous duty, repetitive switching or transfer between two active power sources are not accepted.

(2) The Automatic Transfer Switches shall be of double throw construction and electrically operated by a single-solenoid mechanism, monetarily energized in the event of normal supply failure, and can also be operated manually I the event of control circuit failure.

(3) The Automatic Transfer Switches shall have the characteristic as follows:

(a) Number of pole : 4

(b) Rated Voltage : 415-Y/240V

(c) System Voltage : 380-Y/220V

(d) Rated Frequency : 50 Hz.

(e) Rated Continuous Current : as per the design at the detailed design stage.

(f) Enclosure : IP 31

1.5.2.2 Component

(1) The automatic transfer switch shall conform to the requirements of IEC 60947-6-1 standard.

(2) Automatic transfer switch shall be 4 pole solenoid operated double throw switch type with 100% rated for both normal utility power source and essential power source and shall be electrically and manual operated, off their respective power sources, as a common transfer mechanism to provide double throw switching action. Microprocessor control panel shall be the same manufacturer as automatic transfer switch.

(3) Transfer mechanism shall be interlocked, electrically and mechanically by own structure, to prevent load circuits from being connected simultaneously to the normal utility and reserve power sources. The operating mechanism shall be such that the load circuit cannot remain permanently switched off from both the normal and the alternative supplies. The main contact positions shall consist of normal and alternative position.

(4) The neutral pole shall have the same withstand and operational rating as the other poles and shall be arranged overlapping.

(5) All contacts in the automatic transfer switch are to be fully shrouded or fitted with arc shields and the cable terminal connections shall be provided with additional heat shrinkable sleeves and covered with removable insulation cover or barrier.

(6) Each transfer switch shall be provided with normal utility 3 phase voltage monitoring circuits of the close differential type, field adjustable, factory set to drop-out should normal utility voltage fall below 80 percent in any phase and to pick-up when normal utility voltage returns to 90 percent in all 3 phases.

(7) The operating sequence of ATS consists of an automatic transfer of a load from the normal supply to an alternative supply in the event of a monitored voltage supply deviation and automatically returning the load to the normal supply when it is restored. The transfer and re-transfer shall be with a predetermined time delay setting ranged 0 to 30 second. If the alternative supply should fail while carrying the load, re-transfer to the normal supply shall be made instantaneously upon restoration of the normal supply on all phases. In case of both the normal and the alternative supplies being present, the ATS shall assume the normal supply position.

(8) Each transfer switch shall be provided with position indicating lamps plus a test switch to simulate failure of the normal utility power source. Transfer switches shall not automatically transfer to the essential power source unless essential power source voltage is established as sense by single phase voltage monitors. Each transfer switch shall include an indicating lamp that shall illuminate when normal utility voltage is available.

(9) The Automatic Transfer Switch shall have to be provided with the auxiliary contacts as monitoring signal to BMS and SCADA in order to confirm healthy and fault status for each the normal and emergency position.

1.5.3 Execution

1.5.3.1 Installation

(1) The Private Party shall install the automatic transfer switches (ATS) and its accessories in accordance with the approved Working Drawings and manufacturer's instructions, and in compliance with the requirement of NFPA 70; and the recommendation of PEA.

(2) The equipment shall be installed as recommended and certified by the manufacturers.

1.5.3.2 Testing and Commissioning

(1) The complete Automatic Transfer Switch shall be factory tested to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency and the time delay settings are in compliance with the specification requirements.

(2) The Automatic Transfer Switches shall be field inspection tested by Manufacturer's authorized representative.

1.6 UNINTERRUPTIBLE POWER SUPPLY (UPS)

1.6.1 General

1.6.1.1 General Requirement

(1) The Private Party shall furnish and install the completely Uninterruptible Power Supply (UPS), batteries and its necessary components as specified hereafter and as indicated on the approved drawings at the detailed design stage.

(2) This specification covers only the general requirements for the UPS system.

1.6.1.2 Standard and Reference

The UPS units, batteries and its necessary components shall comply with the following codes and standards:

(1) IEC 60146-1-1 : Semiconductor converters - General requirements and line commutated converters - Part 1-1: Specification of basic requirements

(2) IEC 60950-1 : Information technology equipment - Safety - Part 1: General requirements

(3) IEC 61000-4-3 : Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test

(4) IEC 62040-2 : Uninterruptible power systems (UPS) - Part 2: Electromagnetic compatibility (EMC) requirements

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

(6) IEC 60896-21 : Stationary lead-acid batteries - Part 21: Valve regulated types - Methods of test

(7) IEC 60896-22 : Stationary lead-acid batteries - Part 22: Valve regulated types - Requirements

1.6.1.3 Submittals

(1) The Private Party shall submit material lists and technical data including schematic diagram for approval prior to proceed purchasing order.

(2) The Private Party shall submit the following technical data for approval before installation.

   (a) Installation detail drawings of the UPS and Stationary Batteries (Dimension plan, section view, required clearances and location of all associate equipment).

   (b) Installation detail drawings of Cables & Raceways and its accessories connected with the UPS and Stationary Batteries.

   (c) Installation and operation manuals.

(3) The Private Party shall submit calculation sheets for batteries capacity which based on 25°C operating temperature.

(4) The Private Party shall submit the battery de-rating curve and the life expectancy decreasing data due to room temperature variation.

(5) The Private Party shall submit the necessary list of spare parts and special tools recommended.

1.6.1.4 Quality Assurance

(1) The equipment manufacturer shall be latest ISO 9001 certified.

(2) All parts of the UPS including its performance shall be guaranteed by the manufacturer and/or the Private Party at least two years after handover.

(3) The life time of each battery shall be at least ten (10) years at 25°C with five (5) years product warranty.

1.6.2 Materials

1.6.2.1 Description

(1) The UPS system shall be True Online Double Conversion System consisting rectifier/charger unit, inverter unit, static bypass switch, manual bypass switch, battery bank, sealed lead acid batteries and other equipment necessary for completion of the system.

(2) The UPS shall be a dual unit parallel-redundant type with configuration as specified on the detailed design stage, and suitable for continuous operation.

(3) Environmental Conditions

The UPS shall be capable of withstanding any combination of the following environmental conditions without mechanical or electrical damage or degradation of operating characteristics.

(a) Ambient Temperature

(i) Operation : 0°C to 40°C

(ii) Storage : 0°C to 60°C

(b) Ambient Temperature

(i) Operation : 0 to 95% for above temperature

(ii) Storage : Same as above

(4) Operation Mode

(a) Normal Mode

(i) During normal mode operation, the AC supply line from utility shall supply power to the rectifier/charger which converts AC power to the regulated DC power (+1% accuracy). Simultaneously, the regulated DC power shall be used to float-charging the batteries while it supplies the inverter.

(ii) The inverter shall invert DC power into AC power for supplying critical loads within specified parameters.

(b) Emergency Mode

(i) Upon failure or loss of the main AC supply line, the critical loads shall be still continuous supplied, without any switching, interruption or excessive disturbance, by the batteries through the inverter.

(ii) Upon restoration of main AC supply line, the rectifier/charger shall recharge the batteries in preparation for future utility line failure and still supply full rated power through the inverter to the loads without interruption.

(iii) The UPS shall shut down itself if the batteries are discharged to their minimum discharge voltage. These batteries shall be able to supply rated output power for the time specified hereafter.

(c) Bypass Mode

(i) Automatic Bypass

1) The static bypass switch shall automatically transfer the load synchronously and without interruption, to the reserve supply in the event of any UPS malfunction (system overload, heavy in-rush current, etc. or inverter shutdown) which could cause the load to deviate beyond the specified tolerance. Upon restoration of the UPS function, the output of the UPS shall be synchronized with the reserve supply and then the load shall be allowed to transfer from the static bypass switch to the inverter without interruption.

(ii) Manual Bypass (Built-in)

1) If the UPS must be taken out of service for maintenance or repair, a manually operated mechanical bypass system shall be provided to avoid the danger of working on live part, this system shall be designed to isolate the inverter

and static switch while maintaining the critical loads via the reserve supply.

2) Transfer by the manual bypass or re-transfer back to the UPS system shall take place synchronized with the reserve supply (or main supply in case of re-transfer) and with no disturbance to the loads.

(5) Physical Requirement

(a) The UPS equipment shall be housed in a free-standing, floor mounted with protection degree at least IP 21 cubicle, designed for heavy-duty industrial applications and constructed of steel, or equivalent. All components and materials shall be new version of the current state-of-the-art.

(b) All equipment in the system shall form a match and line-up configuration.

(c) Equipment shall be designed for front access.

(d) Enclosures shall be coated with several coats of anti-sulphuric or anti-alkaline enamel inside and outside within the manufacturer standard color. All equipment doors shall be hinged and provided with lockable handles (all keyed alike), or pad-lockable handles.

(e) All status, alarm and instrumentation displays and all normal operator controls shall be visible and accessible to a person standing on the floor.

(f) All power circuit sub-assemblies except major magnetic shall have the capability of insertion or removal by one person without the use of mechanical means except to remove screws/bolts. Sub-assemblies performing similar functions shall be interchangeable. All power connections shall be bolted and readily accessible.

(g) Control sub-assemblies shall be in racks or trays. Printed circuit boards shall be grouped according to function in a single location/rack in the module.

(6) Protective Devices Requirement

The following protective devices and system shall be equipped within the UPS system:

(a) AC switches with fuses for main AC input protection

(b) DC Circuit Breakers for DC input protection

(c) AC switches with fuses for AC output protection

(d) Alarm warning system for the Rectifier, Charger, Inverter and Bypass Switch

(7) Performance Requirement

(a) Overload : ≥ 125% for 10 minutes

: ≥ 150% for 1 minute

(b) Overall efficiency : ≥ 90% at 50% load to 100% load and ≥ 70% while recharging the battery.

(c) Back-up time : 3 hours for 100% load, 0.8 pf lagging

(d) Noise level : ≤ 65 dBA measured at 1.5 m from front panel

1.6.2.2 Component

(1) Rectifier/Charger Unit

(a) The unit shall be a totally isolated 6 or 12 pulses rectifier/charger, fully control bridge type with anti-harmonic choke.

(b) The unit shall be a complete set manufacturing from the factory.

(c) Electrical characteristic of the unit shall be as listed below:

(i) Rated input voltage : 400/230 Volts ac ± 15%, 3Ø, 4W with Earth

(ii) Input frequency : 50 Hz ± 10%

(iii) Input power factor : ≥ 0.95 lagging

(iv) Input THDi : ≤ 5% at rated load

(v) Input Current limiting : adjustable from 100% to 125%

(vi) DC output voltage regulation : ± 1%

(2) Inverter Unit

(a) The unit shall be solid state, IGBT Transistor type which is designed for Pulse Width Modulation technology interconnected with 3-phases isolation transformer and filter capacitor.

(b) Output terminal of the unit shall be busbars type with a neutral bus size not less than 1.5 times of the rated current.

(c) Electrical characteristic of the unit shall be as listed below:

(i) Rated output power (kVA) : as per the design at the detailed design stage (at power factor 0.8 lagging)

(ii) Output voltage, Transient and recovering

1) Steady state : 400/230 Volts ac ± 15%, 3Ø, 4W with Earth

2) Transient 0% - 100% step load : ± 3% of rated voltage

3) Transient recovery time : ≤ 50 ms for non-linear load and ≤ 20 ms for linear load

4) Voltage imbalance : ≤ 1.5% at 50% unbalance load

5) Phase Displacement : $\leq \pm 2.5^{\circ}$

(iii) Output frequency

1) Steady state : 50 Hz ± 1%

2) Free running : 50 Hz ± 0.1%

3) Slew rate (df/dt) : 1 Hz/sec – 2 Hz/sec adjustable

(iv) Output harmonic distortion (THDu)

1) 100% linear load : ≤ 3%

2) 100% non-linear load : ≤ 5%

(3) Static Bypass Switch

(a) The static bypass switch shall be designed to bypass the critical load from the inverter to the main power source in the event of UPS malfunctions without interrupting the critical load operation.

(b) The static bypass switch shall be rated at least to carry full load continuously, and shall be able to withstand any internal and external fault current not less than ten (10) times of full load within 20 milliseconds.

(4) Battery Bank

The battery bank shall at least consist of the following:

(a) Set of batteries, in split banks to enable maintenance.

(b) Battery racks, which shall be coated by acid resistant material from the factory.

(c) Associated equipment of the battery, panel board and isolators.

(d) Grounding system.

(5) Battery

(a) The battery shall be Valve Regulated Sealed Lead Acid (VRSLA) type. The plates shall be enclosed in polypropylene containers with safety release valve.

(b) The battery shall have capability to deliver the output power rating as specified on the drawings at the output terminal of the UPS for at least 3 hours in the event of input power to the UPS failure.

(c) The maximum and minimum voltage of the battery shall be matched with the operating input voltage of the inverter. The minimum final discharge voltage of the battery shall be limited at 1.7 or 1.75 V/Cell or at the recommendation value from the manufacturer.

(6) Associated Equipment of the Battery

(a) The battery cell inter-connectors shall be copper bar and fully insulated. All bolts and nuts shall be of the acid resistant type.

(b) All battery terminal posts shall be covered with soft rubber pole caps to prevent external short circuit.

1.6.2.3 Control and Annunciation System

(1) The UPS shall incorporate the necessary control, instruments and annunciation to perform the completed function and to allow the operator to monitor the system status and performance as well as to take any appropriate action.

(2) The control and annunciation system shall be micro-processor based control which complete with LCD display for monitoring of events (≥ 500 events) log alarm and measured values.

(3) The visible and audible alarm for the UPS shall be provided.

(4) The minimum requirement of the measuring values for monitoring shall be as listed:

(a) Input : Voltage, Current, Frequency, Energy, Power

(b) Output : Voltage, Current, Frequency, Energy, Power

(c) Battery Output : Voltage, Current, Real back-up time, Temperature, % Load

(5) The minimum requirement of the status and alarm for monitoring shall be as listed:

(a) Rectifier : Off, Over Temperature, Failure

(b) Inverter : Off, Over Temperature, Failure

(c) Battery : On Load, Over Temperature

(d) Load on Bypass

(e) Overload

1.6.2.4 Network Interfacing

(1) The Network/Communication Port (RS485 or 10/100 Base-T or etc.) shall be provided within the UPS for remote monitoring and management.

(2) The interface units shall be provided to interface with Building Management System (BMS) and SCADA for remote monitoring and management in SOR and OCC respectively.

(3) The UPS and Battery management software with license number shall be provided.

1.6.3 Execution

1.6.3.1 Installation

(1) The Private Party shall install the UPS and Battery Bank including associate equipment in accordance with the approved Working Drawings and manufacturer's instructions.

(2) The installation, size of cables and conduits shall be followed the instruction from manufacturer.

1.6.3.2 Testing and Commissioning

Upon completion of installation, the UPS and associate equipment shall be tested within the minimum requirement as follow:

(1) The system shall be tested involving electrical characteristic as specified in Item 13.10.2.2 for load condition in a period of not less than 8 hours.

(a) No Load

(b) 50% Load (Dummy Load)

(ci) Full Load (Dummy Load)

(2) Record Input and output voltage/current wave form, which are measured in each load condition of 0%, 25%, 50%, 75% and 100%.

(3) Measure and record overall efficiency at 100% load in each condition of main power supply from utility line and from batteries.

(4) Test grounding of the system.

1.7 BUSWAYS

1.7.1 General

1.7.1.1 General Requirement

(1) The Private Party shall furnish and install the Busways and its accessories as specified hereafter and as indicated on the approved drawings at the detailed design stage.

1.7.1.2 Standard and Reference

The busways and its components shall comply with the following codes and standards:

(1)	IEC 61439-6	:	Low-voltage switchgear and controlgear assemblies - Part 6: Busbar trunking systems (busways)
(2)	IEC 60529	:	Degree of protection provided by enclosures (IP Code)
(3)	UL 857	:	Busways
(4)	NFPA 70	:	National Electrical Code

1.7.1.3 Submittals

(1) The Private Party shall submit material lists and technical data for approval prior to proceed purchasing order. Final field measurements shall be made by the Private Party prior to release for fabrication to assure coordination with other works.

(2) The Private Party shall submit the installation method and details for approval before installation.

1.7.1.4 Quality Assurance

(1) The Busways manufacturer shall be latest ISO 9001 certified.

(2) All parts of the Busways and its accessories shall be guaranteed by the manufacturer and/or the Private Party at least two years after handover.

1.7.1.5 Delivery and Handling

(1) The Busways and its accessories shall be stored and handled in accordance

with manufacturer instruction.

1.7.2 Materials

1.7.2.1 Description

(1) In general, the Busways system shall be comprised of low impedance plug-in and/or feeder busway, fittings, hanging devices and other necessary accessories.

(2) The Busways shall be of rectangular section fabricated from hard drawn high conductivity copper, electrolytic plated with tin or silver. The neutral bus shall be fully rated as the phase bus.

(3) The rated symmetrical short circuit capacity (rms) shall be not less than the rated short-time of the associated Main LV Switchboards as specified on the detailed design stage.

(4) Each busbars shall be totally enclosed and insulated with 130°C Class B insulating material. Insulated and anti-tracking supports for busbars shall be provided at regular spaces intervals of 300mm and 600 mm. The supports shall be suitable for use of the Busways in any position.

(5) Jointing of the Busbars shall be bridge joint design in accordance with the recommendations of the Manufacturer, using purpose-made links throughout.

(6) The busways system shall comply with the minimum requirement as follow:

(a)	Rated voltage	:	3-Phase, 4-wires, 400/230V, 100% neutral, 50% ground
(2)	Rated current	:	as per the design at the detailed design stage
(3)	Protection class	:	IP 54
(4)	Voltage drop	:	Less than 3.5 V/30 meters, 0.8 PF., 80°C

1.7.2.2 Component

(1) Busway

(a) The housing shall be of galvanized steel sheet or aluminium with epoxy paint to provide maximum protection against corrosion from water and other contaminants normally encountered during construction. All hardware shall be plated to prevent corrosion.

(b) The busway which run from electrical room to shaft or to the next electrical room shall be feeder type. The busway run along electrical shaft which feed power to each floor shall be plug-in type.

(c) Bus bars shall be suitably plated at all joints and contact surfaces.

(d) All insulation material shall be NEMA class B.

(e) For the plug-in type busway, the housing shall completely enclose the switching device and shall be of sheet steel furnished in grey enamel over a rust inhibitor. A ground slab to engage grounding tab on busway shall be provided. Provide means for padlocking cover and operating handle in "OFF" position. All current-carrying parts shall be suitably plated.

(f) For the plug-in type busway, A releasable cover interlocking shall be provided to prevent opening cover except when switch is in "OFF" position. A releasable interlock preventing closing switch with cover open shall also be included, as well as an interlock to prevent insertion or removal from busway when in "ON" position.

(2) Fittings

(a) Tie bolts shall brace aluminum housing and bars to withstand, without damage or permanent distortion, short-circuit currents of the magnitude shown on the drawings when tested in accordance to UL standard. Busway shall be finished in grey enamel.

(b) Joints shall be of the one-bolt removable/isolatable type with through-bolts that can be checked for tightness without de-energizing the system. It shall be possible to make up a joint from one side in the event the busway is installed against a wall or ceiling. The joint shall be so designed as to allow removal of any length without disturbing adjacent lengths. Springs shall be provided to give positive pressure over complete contact area. Plug-in and feeder shall use identical parts, and all multi-stacks shall be phase collected.

(c) The maximum hot-spot temperature rise at any point of busbar at continuous rated load shall not exceed 55°C above a maximum ambient temperature of 40°C in any position.

(3) Plug-in Unit (if applied)

(a) The plug-in unit shall have an interrupting rating (kA rms symmetrical at 415 VAC) as indicated on the approved Drawings at the detailed design stage. They shall have a releasable cover interlock that prevents opening of cover except with breaker in "OFF" position. An interlock to prevent insertion or removal from busway when in "ON" position shall be provided, as well as an interlock (releasable) to prevent closing circuit breaker with cover open.

(b) Connection between power clamp of plug-in type busway and circuit breaker shall be busbar with insulation.

1.7.3 Execution

1.7.3.1 Installation

(1) The Busways shall be installed so that the maximum unsupported span of horizontal runs does not exceed 3 meters. Vertical riser runs of busway shall be supported with rigid and/or spring hangers in positions indicated on plans (max 5 m. centers).

(2) All equipment shall be installed as recommended and certified by the manufacturers.

(3) Provide necessary fittings, expansion joints, hanging devices, and accessories as required for the installation.

(4) Provide a fire barrier where busway or busbar trunking pass through a fire-rated wall, floor or ceiling. Assemble busways from standardized sections so that the complete system shall be rigid in construction and neat and symmetrical in appearance.

1.7.3.2 Testing and Commissioning

(1) The busways insulation shall be meggered phase-to-phase and phase-to-ground before the equipment is connected and phase-to-ground after the equipment is connected.

(2) The busways insulation resistance testing shall be performed by using a 1000 V.dc Megger or as per the standard testing from the manufacturer.

(3) Insulation resistance shall be not less than five (5) mega-ohms or as the standard certified by the manufacturer.

1.8 LOW VOLTAGE CABLES

1.8.1 General

1.8.1.1 General Requirement

(1) The Private Party shall furnish and install the low voltage cables and accessories as specified hereafter and as indicated on the approved drawings at the detailed design stage.

1.8.1.2 Standard and Reference

The power cable shall comply with the following codes and standards:

(1)	IEC 60227-1	:	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V - Part 1: General requirements
(2)	IEC 60228	:	Conductors of insulated cables
(3)	IEC 60502-1	:	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1.2 kV) up to 30 kV (Um = 36 kV) - Part 1: Cables for rated voltages of 1 kV (Um = 1.2 kV) and 3 kV (Um = 3.6 kV)
(4)	IEC 60331-1	:	Tests for electric cables under fire conditions - Circuit integrity - Part 1: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0.6/1.0 kV and with an overall diameter exceeding 20 mm
(5)	IEC 60331-2	:	Tests for electric cables under fire conditions - Circuit integrity - Part 2: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0.6/1.0 kV and with an overall diameter not exceeding 20 mm
(6)	IEC 60331-11	:	Tests for electric cables under fire conditions - Circuit integrity - Part 11: Apparatus - Fire alone at a flame temperature of at least 750 °C
(7)	IEC 60332-1-1	:	Tests on electric and optical fibre cables under fire conditions - Part 1-1: Test for vertical flame propagation for a single insulated wire or cable – Apparatus
(8)	IEC 60332-3-10	:	Tests on electric and optical fibre cables under fire conditions - Part 3-10: Test for vertical flame spread of vertically-mounted bunched wires or cables – Apparatus
(9)	IEC 61034-2	:	Measurement of smoke density of cables burning under defined conditions - Part 2: Test procedure and requirements
(10)	IEC 60754-2	:	Test on gases evolved during combustion of materials from cables – Part 2: Determination of acidity (by pH measurement) and conductivity

(11) TIS 11-2553 : Thai Industrial Standard for PVC insulated copper cables

(12) BS 6387 : Test method for resistance to fire of cables required to maintain circuit integrity under fire conditions

(13) NFPA 70 : National Electrical Code

(14) EIT 2001-56 : Thai Electrical Code 2013

1.8.1.3 Submittals

(1) The Private Party shall submit the technical data, catalogues, cable installation drawings, cable routes, cable connection and other necessaries of the low voltage cables for approval prior to proceed purchasing order and installation.

(2) Type-tested certificate and Routine test reports, as necessary for each type of cable in accordance with the aforementioned standards, shall be submitted. The Type-tested certificates shall be issued by an international independent third-party testing authority/institute (such as ASTA, LPCB, KEMA, TÜV or other institutes according to the Engineer's Representative deem appropriate). The Certificates shall be clearly indicated about the recent valid date-month-year of approval.

1.8.1.4 Quality Assurance

(1) The equipment manufacturer shall be latest ISO 9001 certified.

(2) All parts of the equipment and its accessories including installation shall be guaranteed by the Private Party at least two years after handover.

1.8.2 Materials

1.8.2.1 Description

(1) Power cables will be single, two, three or four conductors depending on the design in the detailed design stage which being used in a 3-phase - 4-wire - 50 Hz - solidly grounded system.

(2) All cables shall be selected suitably for indoor and outdoor installations, wet and dry locations, exposed to sunlight, in conduit, in cable tray, in wireway as appropriate.

(3) The conductors shall be unbroken for the full length of the reels.

(4) Cables for life safety equipment shall be fire resistance cables (FR).

1.8.2.2 Component

(1) PVC insulated cable

(a) The cables shall be formed of individually annealed copper solid or stranded wire with heat resistant Polyvinyl chloride (PVC) insulation material which has rated not less than 750 V 70^{O}C in compliance with TIS 11-2553 standard.

(b) All cables size 6 mm^2 or larger shall be stranded.

(2) XLPE Insulated Cable

(a) Conductors shall be of soft or anneal uncoated stranded copper wire Class 2 in accordance with IEC 60228 and shall have a concentric lay.

(b) Insulation shall be of cross linked polyethylene (XLPE) insulated and black Polyvinyl chloride (PVC) outer sheathed, which have rated not less than 0.6/1.0 kV 90^{O}C in compliance with IEC 60502 standard.

(c) For multi-core conductor cable, the component of cable shall consist of Conductors (2 or 3 or 4 cores), Insulation (XLPE), Filler, Binding Tape, and Outer Sheath (PVC). Filler shall be of non-hygroscopic material.

(3) Fire Resistant Cable (FR Cable)

(a) Conductors shall be of soft or anneal uncoated stranded copper wire in accordance with IEC 60228.

(b) Insulation shall be consisted of fire resistance tape (mica tape, etc.) cover the copper conductor and the outer shall be cross-linked polyethylene (XLPE) or polyolefin insulation which has thickness according to IEC 60502.

(c) Outer sheath shall be of polyethylene or other material that have low smoke and zero halogen (LSF or LSOH or LSZH).

(d) For multi-core conductor cable, the component of cable shall consist of Conductors (2 or 3 or 4 cores), Insulation, Filler, Binding Tape, and Outer Sheath. Filler shall be of low smoke/zero halogen material.

(e) Rated voltage of cable shall be 0.6/1.0 kV.

(f) Cable shall not generate toxic gases in event burnt.

(g) Standard for Testing of Fire Resistance shall be in compliance with BS 6387 Category C, W, Z or/and IEC 60331-1 / -2 / -11.

(h) Standard for testing of flame retardant shall be in compliance with IEC 60332-1 / -3.

(i) Standard for testing of smoke emission shall be in compliance with IEC 601034-2.

(j) Standard for testing of toxic gas emission shall be in compliance with IEC 60754-2.

(k) Test reports shall be submitted for approval.

(l) Cable fittings in each junction box shall be fire resistant type.

(4) Low Smoke/Zero Halogen Cable (LSF or LSOH or LSZH Cable)

(a) Conductors shall be of soft or anneal uncoated stranded copper wire in accordance with IEC 60228.

(b) Insulation shall be cross-linked polyethylene (XLPE) or polyolefin insulation which has thickness according to IEC 60502.

(c) Outer sheath shall be of the low smoke/zero halogen material.

(d) For multi-core conductor cable, the component of cable shall consist of Conductors (2 or 3 or 4 cores), Insulation, Filler, and Outer Sheath. Filler shall be of low smoke/zero halogen material.

(e) Rated voltage of cable shall be 0.6/1.0 kV.

(f) Cable shall not generate toxic gases in event burnt.

(g) Standard for testing of flame retardant shall be in compliance with IEC 60332-1 / -3.

(h) Standard for testing of low smoke shall be in compliance with IEC 601034-2.

(i) Standard for testing of toxic gas emission shall be in compliance with IEC 60754-2.

(j) Test reports shall be submitted for approval.

(5) Control Cable (CVV and CVVs)

(a) All control cable shall be suitable for installation in wet and dry locations. The conductor shall be of soft or annealed strand uncoated copper wire.

(b) The insulation shall be polyvinyl chloride (PVC) or polyethylene (PE) suitable for use on a copper conductor with a maximum operating temperature not less than 70^{o}C.

(c) Filler shall be used in the interstice of the multi-conductor cable where necessary to give the complete cable a substantially circular cross section. Fillers shall be Polyvinyl chloride (PVC) rod or Polyethylene (PE) materials.

(d) The cable shall be helically wrapped over the filler and copper shielding with non-hygroscopic Mylar or Polyester tape.

(e) The shielding, for CVVs cables, shall be annealed copper tape or suitable width and shall be helically applied with a minimum 10% lap. The annealed copper tape shall be a least 0.1mm thickness and substantially free from burrs.

(f) The outer sheath shall be of black polyvinyl chloride (PVC) jacket over the wrapping and shall comply in all respects with ICEA S61-402 standards.

(g) For life safety equipment; the control cables shall be fire resistant type complying with the standards as shown in item (5) “Fire Resistant Cable (FR cable)”.

1.8.3 Execution

1.8.3.1 Installation

(1) In general, the Power cables shall be run in conduits, in cable tray and shall be run concealed in ceiling, floor, and wall or as indicated on the approved Working Drawings.

(2) No wire shall be pulled into the conduit system until it is complete in all details.

(3) Lubricant shall be used to facilitate wire pulling. Lubricants shall be approved for using with the insulation specified.

(4) Splicing of wires and cables shall be allowed only in the luminaires, receptacles and proper junction box with an approved method of insulation. No splice shall be made in conductors for instrument circuits or control circuits.

(5) Splicing of large wires and cables shall be by compression type, solderless wire connectors indented by special hydraulic tool. The splice shall be insulated with plastic insulation tape such as Scotch Brand No.35. Thickness of the tape shall not be less than three layers or at least the same thickness as the wire insulation.

(6) Compression type, solderless lugs indented by proper tool shall be used at the end of all wires and cables and shall be connected to the screw type terminals of the equipment and to the bus bars.

(7) The cut end of cables shall be treated to prevent seepage of water into the cable.

(8) The Private Party shall provide all necessary materials for installation of the cables, such as grounding lead wires, compression type terminals, metal fitting, bolts and nuts including cable identification and felt packing to be inserted between cable and cleats.

(9) The unoccupied space in cable knockouts and conduits after cable insertion shall be filled, with duct seal to prevent insects and small animals from entering the equipment housing.

(10) Where cables are buried in the ground the minimum depth of burial shall be 0.6 m. Cables shall be laid on 0.15 m and covered by a 7.5 cm. layer of clean sand. Cables shall be covered with tiles and or marking tape and the trenches backfilled to grade level.

(11) Cables under roads shall be enclosed in ducts supplied and installed by the electrical work.

(12) All cables shall be identified by means of cable tags fitted to each termination point and at 30 meter intervals along cable route.

(13) Cable route markers shall be installed above ground along underground cable routes. These shall be located at 30 meter inter- intervals, at changes of direction and at entries to buildings.

(14) The Private Party shall be responsible for the supervision of the cable trench excavation, sanding and backfilling, supply and installation to warning tape, cable tiles and cable marker posts as detailed on the approved Working Drawings and in these Specifications.

(15) Cables shall be laid in one continuous length.

(16) Conductors with compression type terminals and insulation cover shall be arranged in a neat manner on terminal box or equivalent terminals. The Private Party shall install plastic cable tie-wraps as required to neatly group cables and to keep the weight of the cable from damaging terminations.

(17) The conductors in vertical raceways shall be supported if the vertical rise exceeds the values in following table:

Spacing for Conductor Supports in Vertical Raceway		
Size of Cable (mm^2)	**Maximum Spacing (m)**	**Remark**
50 or smaller	30	If the vertical run is less than 25% of max. Spacing in table, cable supports will not be required.
70 thru 120	24	
150 thru 185	18	
240	15	
300	12	
over 300	10	

(18) Color coding for the low voltage cables shall be as follow:

(a) Phase A : Brown

(b) Phase B : Black

(c) Phase C : Gray

(d) Neutral : Light Blue

(e) Ground : Green or Green-with-Yellow strip

(f) Large wires and cables shall be color coded with suitable heat shrinkable sleeves as the specified color.

1.8.3.2 Testing and Commissioning

(1) All power cables shall be meggered phase-to-phase and phase-to-ground before the equipment is connected and phase-to-ground after the equipment is connected and all connection are tapped.

(2) Insulation resistance tests shall be performed by using a 500 Vdc megger on the 400 volts system. Insulation resistance shall be not less than one mega ohms per 1000 volts rating.

1.9 RACEWAY

1.9.1 General

1.9.1.1 General Requirement

(1) The Private Party shall furnish and install the Raceway (Conduits, Cable Trays and Wireways) and their accessories as specified hereafter and as indicated on the approved drawings at the detailed design stage.

1.9.1.2 Standard and Reference

The Conduits, Cable trays, Wireways and their accessories shall comply with the following codes and standards:

(1)	ANSI/NEMA FB 1	:	Fittings, Cast Metal Boxes and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
(2)	ASTM A123/A123M-13	:	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
(3)	ASTM D1248	:	Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
(4)	NEMA ANSI C80.1	:	Electrical rigid steel conduit (RSC)
(5)	NEMA ANSI C80.3	:	Steel electrical metallic tubing (EMT)
(6)	NEMA ANSI C80.6	:	Electrical intermediate metal conduit (IMC)
(7)	TIS 770-2533	:	Standard for Zinc coated steel conduits for electrical wiring
(8)	IEC 60529	:	Degree of protection provided by enclosures (IP Code)
(9)	NFPA 130	:	Standard for Fixed Guideway Transit and Passenger Rail Systems
(10)	NFPA 70	:	National Electrical Code
(11)	EIT 2001-56	:	Thai Electrical Code 2013

1.9.1.3 Submittals

(1) The Private Party shall submit the technical data and catalogues of the conduits, cable trays and wireways with sample material for approval prior to proceed purchasing order.

(2) The Private Party shall submit the installation details and routing plans of the conduits, cable trays and wireways for approval before installation.

1.9.1.4 Quality Assurance

(1) The equipment manufacturer shall be latest ISO 9001 certified.

(2) All parts of the equipment and its accessories including installation shall be guaranteed by the Private Party at least two years after handover.

1.9.2 Materials

1.9.2.1 Conduits

(1) General Requirement

(a) Minimum Size: ø15 mm. (ø1/2 inch).

(b) For underground installations:

(i) Where embedded in compact soil or sand:

Use HDPE type or as indicated on the approved drawings at the detailed design stage.

(ii) Where embedded in concrete encasement:

Use RSC or HDPE type or as indicated on the approved drawings at the detailed design stage.

(c) For being embedded in reinforced concrete wall or slab:

Use IMC or RSC type or as indicated on the approved drawings at the detailed design stage.

(d) For being embedded in masonry wall or light wall:

Use EMT or IMC type or as indicated on the approved drawings at the detailed design stage.

(e) For installations on any surface:

(i) Outdoor locations:

Use IMC or RSC type or as indicated on the approved drawings at the detailed design stage.

(ii) Indoor locations:

- Use EMT or IMC type or as indicated on the approved drawings at the detailed design stage.
- Conduits and accessories installed inside all Stations shall be capable of being subject to temperatures up to 500°C for 1 hour and shall not support combustion under the same temperature, in accordance with NFPA 130.

(f) The conduits shall have to be specified in SI units on the Drawings. And the table below shall be the conversion of diameters of conduits from inch to millimeter.

Conduit Diameter in Inches	½	¾	1	1 ¼	1 ½	2	2 ½	3	3 ½	4
Conduit Diameter in mm	15	20	25	32	40	50	65	80	90	100

(2) Materials Description

(a) Rigid Steel Conduit (RSC), if applied, shall be hot-dip galvanized rigid steel in compliance with aforementioned standards and complete with enamel finished inside the tube.

(b) Intermediate Metal Conduit (IMC) shall be hot-dip galvanized rigid steel in compliance with aforementioned standards and complete with enamel finished inside the tube.

(c) Electrical Metallic Tubing (EMT) shall be hot-dip galvanized steel in compliance with aforementioned standards and complete with enamel finished inside the tube.

(d) The RSC and IMC conduit shall be in standard length of approximately 3.00 meters including coupling, one coupling to be furnished with each length. Each length shall be reamed and threaded on each end.

(e) Flexible Metal Conduit (FMC) shall be made from galvanized steel in compliance with TIS 2133-2545. The FMC installed in wet locations shall be of the liquid-tight type in compliance with BS 731 or IEC 60754-1 or IEC 61034-2 or BS EN50086-1. Flexible conduit and fittings for life safety equipment shall be made of galvanized steel water-tight pattern, frame retardant; LSOH over-sheathed and separated earth wire enclosed within the conduit.

(f) Conduit fittings and conduit bodies shall be hot-dip galvanized steel in compliance with aforementioned standards and weatherproof type, and bushing shall be grounded type.

(g) The finished conduit and fittings shall have smooth surface, free of lumps of excess zinc, inside bead or other injurious defects or such defects detrimental to smooth wire pulling.

(h) The outside surface and threads on conduit shall have protective coating against corrosion. The threads on the fittings shall have paint, zinc or other protective coating against corrosion.

(i) The standard manufactured Elbows shall be used for all sizes of conduits larger than 25 mm. (1 inch). The field bends to be handles with great care not to damage the conduits, will be permitted for conduit of 25 mm. (1 inch) and smaller.

(j) High Density Poly-Ethylene Conduit, if applied, shall be in compliance with ASTM D1248:

- Class I: For being embedded under road or street.
- Class II: For being embedded under pavement or footpath.

1.9.2.2 Cable Trays

(1) Cable trays shall be of a perforated/corrugated pattern (as specified in the detailed design stage) with lid, 2.0 mm minimum thickness mild steel and hot-dip galvanized overall after fabrication in compliance with ASTM A123/A123M:13 to protect against corrosion during storage, and to have long service life.

(2) Cable trays, fittings and supports shall be capable of being subject to temperatures up to 500°C for 1 hour and shall not support combustion under the same temperature.

(3) Fittings (such as tees, angle pieces, connectors, etc.) shall be of the same type of the cable trays.

(4) Support brackets and rods shall be of hot-dipped galvanized steel. Minimum mean coating thickness of the hot dipped galvanization shall be 65 micron. All bolts and nuts shall be electroplated with zinc with a minimum plating thickness of 25 micron.

(5) On site cutting of hot dipped galvanized components shall be properly repaired in the field using cold galvanizer.

(6) Connecting joint between cable tray and equipment shall be a flexible joint.

(7) Each section of the cable tray shall be electrically bonded, with a minimum 6 sq.mm cross-sectional area earth-bonding strap or wire, to the next section to form an electrically continuous system and bonded to the main grounding system with green/yellow PVC insulated copper, single core cable. All edges, fittings, or any parts of the cable trays shall be finished free from burrs, sharp edges, or projections damaging to the insulation or jacket of the cables.

(8) The number of cables installed in the cable trays shall be in compliance with the requirements of EIT standard 2001-56 and/or the current edition of NFPA 70. 40% spare space capacity of the cable trays shall be provided for future cables laying inside the cable tray.

1.9.2.3 Wireways

(1) Wireways shall be made of hot-dip galvanized after fabrication to protect against corrosion during storage, installation and to have long service life and shall be provided to form the continuous steel sheet troughs with removable covers attached to the wireway by screws for housing the cables. The minimum thickness of steel sheets (before the galvanized process) for wireways fabrication shall be as the following table (in millimeter unit):

Size of wireways (width x height)	Thickness
50 x 50 up to 100 x 50	1.2
100 x 100 up to 150 x 100	1.6
200 x 100 up to 300 x 100	1.6
150 x 150 up to 300 x 150	2.0

(2) Wireways, fittings and supports shall be capable of being subject to temperatures up to 500°C for 1 hour and shall not support combustion under the same temperature.

(3) Fittings (such as tees, angle pieces, connectors, etc.) shall be of the same type of the wireways.

(4) Support brackets and rods shall be of hot-dipped galvanized steel. Minimum mean coating thickness of the hot dipped galvanization shall be 65 micron. All bolts and nuts shall be electroplated with zinc with a minimum plating thickness of 25 micron.

(5) On site cutting of hot dipped galvanized components shall be properly repaired in the field using cold galvanizer.

(6) Each section of the wireways shall be electrically bonded, with a minimum 6 sq.mm cross-sectional area earth-bonding strap or wire, to the next section to form an electrically continuous system and bonded to the main grounding system with green/yellow PVC insulated copper, single core cable. All edges, fittings, or any parts of the wireways shall be finished free from burrs, sharp edges, or projections damaging to the insulation or jacket of the cables.

(7) The number of cables installed in the wireways shall be in compliance with the requirements of EIT standard 2001-56 and/or the current edition of NFPA 70. 40% spare space capacity of the cable trays shall be provided for future cables laying inside the cable tray.

(8) Floor trunkings, if applied, shall be made of hot-dipped galvanized steel (or better), minimum thickness of 2.0 mm. The floor trunkings shall be provided with knockout holes and water proof fastening cap for removal at outlet points which to be specified on the detailed design stage. Sample and installation details shall be submitted for approval.

1.9.2.4 Boxes and Accessories

(1) Outlet Boxes (for socket outlets, lighting switches, etc.)

(a) The outlet boxes shall comply with the aforementioned standards.

(b) For wall/column recess, the boxes shall be of steel sheet with not less than 1 mm thickness with hot-dip galvanized after fabrication, and completed with adjustable lug, ample knocked-holes and brass earth terminals fitted within the box and with one primer anti-rust coated and two coating finishes.

(c) For exposed works; the boxes shall be of die-cast aluminium, and completed with threaded hubs, neoprene gasket and earth terminal fitted within the box. The boxes shall be allowed for outdoor works in accordance with IP65 protection class.

(d) For floor recess; the boxes shall be of die-cast aluminium or galvanized cast iron, and completed with threaded hubs, neoprene gasket and earth terminal fitted within the box.

(e) The internal depth of a box shall be not less than 32 mm.

(f) The corners of a box shall be mechanically and electrically continuous.

(2) Pull Boxes and Junction Boxes

(a) Pull boxes and junction boxes for branch circuits, indoor used, shall be as the same type of the outlet boxes (clause 1.9.2.4 (1)(b)) and to be equipped with galvanized steel cover plate matching with the boxes which to be fastened with stainless steel screws.

(b) Pull boxes and junction boxes for branch circuits, outdoor used, shall be of die-cast aluminium circular box completed with threaded hubs, earth terminal fitted within the box and fastening cover with neoprene gasket for IP65 protection class.

(c) Pull boxes and junction boxes for branch circuits, in-ground used, shall be of die-cast aluminium rectangular box completed with threaded hubs, earth terminal fitted within the box and smooth cover with neoprene gasket fastened with stainless steel cover screws for IP67 protection class.

(d) Pull boxes, which are used in feeder system (main feeders or feeders or sub-feeders), shall be made of steel sheet with not less than 1.6 mm thickness with hot-dip galvanized after fabrication, completed with ground flange, neoprene gasket and lid fastened with stainless steel screws. The boxes where used on outdoor location shall be IP65 protection class.

(e) The corners of a box shall be mechanically and electrically continuous.

(f) Size of the pull boxes and junction boxes shall be selected in compliance with EIT standard 2001-56 and/or the current edition of NFPA 70.

- (i) Pull boxes and junction boxes for branch circuits, indoor used, shall be as the same type of the outlet boxes (item (5) (a)) and to be equipped with galvanized steel cover plate fastened with stainless steel screws.
- (ii) Pull boxes and junction boxes for branch circuits, outdoor used, shall be of die-cast aluminium circular box completed with threaded hubs, earth terminal fitted within the box and fastening cover with neoprene gasket for IP65 protection class.
- (iii) Pull boxes and junction boxes for branch circuits, in-ground used, shall be of die-cast aluminium rectangular box completed with threaded hubs, earth terminal fitted within the box and smooth cover with neoprene gasket fastened with stainless steel cover screws for IP67 protection class.
- (iv) Pull boxes, which are used in feeder system (main feeders or feeders or sub-feeders), shall be made of steel sheet with not less than 1.6 mm thickness with hot-dip galvanized after fabrication, completed with ground flange, neoprene gasket and lid fastened with stainless steel screws. The boxes where used on outdoor location shall be IP65 protection class.
- (v) The corners of a box shall be mechanically and electrically continuous.

(vi) Size of the pull boxes and junction boxes shall be selected in compliance with EIT standard 2001-56 and/or the current edition of NFPA 70.

1.9.3 Execution

1.9.3.1 Installation

(1) Conduits & Accessories

(a) Where the conduits enter the cabinets and equipment, conduit bushings and double locknuts shall be used.

(b) The end of all conduits shall be tightly plugged to exclude dust and moisture while the buildings are under construction.

(c) The bending radius of the conduit shall not be less than six times the outer diameter of the conduits. The total bending angles of conduits shall not exceed 360 degrees in any one run.

(d) The conduits used shall not have any internal and external defects. Each end of the conduit shall be made smooth with the conduit reamer to prevent damage to the wire.

(e) A short piece of flexible metal conduit shall be used for connecting all motors, vibrating equipment, recess lighting fixtures and junction boxes and as otherwise specified.

(f) The wiring system shall consist of PVC insulated cables drawn into conduit. Wiring shall be loop-in style without joints.

(g) The wiring capacity of conduits shall comply with the requirement in EIT Standard 2001-56 and/or the current edition of NFPA 70.

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

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

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

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

(l) Provide suitable fittings to accommodate expansion and deflection where conduit crosses seismic, control and expansion joints. These fittings shall have grounding continuity.

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

(2) Cable Trays

(a) The supports for horizontally run-cable tray shall be provided such that they shall be capable to adjust vertically. Where tray and ladder systems are supported by drop rods additional restraints shall be included to provide adequate lateral support. Restraints shall be installed at all bends and intersections and at intervals not exceeding 1.5 meters on straight runs. Support rods shall be at least 6 mm diameter. Trapeze or other hangers shall be clamped on the drop rods between two nuts.

(b) Cable tray or ladder shall not be installed across building or structural expansion joints. On horizontal runs the tray or ladder shall be installed with a 20 mm gap at the expansion joint. Supports shall be installed within 150 mm on either side of the joint.

(c) Cable Trays for normal and essential feeders shall be separated independently.

(d) Provide all openings on floors and walls necessary for cable trays unless indicated as being provided by others.

(3) Wireways

(a) All length of the wireways shall be supported by the metal hangers at every interval not more than 1.50 m for horizontal and vertical installation. The supports for horizontal run shall be provided such that shall be able to adjust vertically for neat alignment.

(b) Install wireways so that all signals cables are in wireway separated from wireway having power cables in it. Install metal barriers in pull-boxes to keep power and signal cables separate and divided.

(c) Wireways for normal and essential circuits shall be separated independently.

(d) Provide all openings on floors and walls necessary for wireways unless indicated as being provided by others.

(4) The Conduits, cable trays, wireways and termination boxes for Electrical system shall have to be painted strip color coding at interval 1 m along total length of raceways in accordance with the aforementioned Color coding for Junction boxes in Clause 1.1.3.3.

1.10 LUMINAIRES AND ASSOCIATED EQUIPMENT

1.10.1 General

1.10.1.1 General Requirement

(1) The Private Party shall furnish and install the luminaires and associated equipment as specified hereafter and as indicated on the approved drawings at the detailed design stage.

(2) All components within the luminaires shall preferably be from the same manufacturer to ensure compatibility. All similar items of equipment shall be interchangeable.

(3) Unless otherwise specified, all luminaires offered shall be as per manufacturer's standard except that all luminaires shall be modified, if not already catered for, to accept a conduit termination, without compromising the quality of the product.

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

1.10.1.2 Standard and Reference

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

(1)	IEC 60598-1	:	Luminaires – Part 1: General requirements and tests
(2)	IEC 60598-2-1	:	Luminaires – Part 2-1: Particular requirements – Fixed general purpose luminaires
(3)	IEC 60598-2-2	:	Luminaires – Part 2-2: Particular requirements – Recessed luminaires
(4)	IEC 62504	:	General lighting - Light emitting diode (LED) products and related equipment - Terms and definitions
(5)	IEC 62031	:	LED modules for general lighting - Safety specifications

(6)	IEC 62612	:	Self-ballasted LED lamps for general lighting services with supply voltages > 50 V - Performance requirements
(7)	IES LM-80	:	IES Approved Method – Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules
(8)	IES TM-21	:	Projecting Long Term Lumen Maintenance of LED Light Sources
(9)	IEC 61347-1	:	Lamp controlgear – Part 1: General and safety requirements
(10)	IEC 61347-2-13	:	Lamp controlgear - Part 2-13: Particular requirements for d.c. or a.c. supplied electronic controlgear for LED modules
(11)	IEC 62384	:	DC or AC supplied electronic control gear for LED modules - Performance requirements
(12)	IEC 61000-3-2	:	Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)
(13)	IEC 61000-3-3	:	Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection
(14)	IEC 60923	:	Auxiliaries for lamps - Ballasts for discharge lamps (excluding tubular fluorescent lamps) - Performance requirements
(15)	IEC 60662	:	High-pressure sodium vapour lamps - Performance specifications
(16)	IEC 61167	:	Metal halide lamps - Performance specification
(17)	IEC 62305	:	Discharge lamps (excluding fluorescent lamps) - Safety specifications
(18)	IEC 61048	:	Auxiliaries for lamps - Capacitors for use in tubular fluorescent and other discharge lamp circuits - General and safety requirements
(19)	IEC 61049	:	Capacitors for use in tubular fluorescent and other discharge lamp circuits. Performance requirements

(20) IEC 61547 : Equipment for general lighting purposes - EMC immunity requirements

(21) BS EN 55015 : Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment

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

(23) TIS 1102-2538 : Self-contained Emergency Lighting Luminaires

(24) TIS 2430-2552 : Internally Illuminated Emergency Exit Sign Luminaires for Buildings

(25) TIS 1955-2551 : Lighting and Similar Equipment: Radio Disturbance Limits

(26) IES : Illuminating Engineering Society

(27) EIT Standard 2004-15 : Emergency Lighting System and Emergency Exit Sign Luminaire Standard

(28) EIT Standard 2001-56 : Thai Electrical Code 2013

(29) NFPA 70 : National Electrical Code

1.10.1.3 Submittals

As a minimum, the following shall be submitted to The Engineer’s Representative for approval at the appropriate stages of the works:

(1) Detailed schedule of equipment and components, photometric data, manufacturer's data and samples. Where requested, manufacturer's type test certificates and testing documents shall also be submitted for inspection.

(2) If requested by The Engineer’s Representative, a sample of proposed fixtures shall be submitted. Samples of all local made fixtures shall be submitted for approval prior to proceed purchasing order.

(3) Construction drawings.

(4) Working drawings on the method of fixing and support for each type of luminaires.

(5) Computer calculation printouts for design or re-design or review of the lighting system as required by The Engineer’s Representative.

1.10.1.4 Quality Assurance

(1) The equipment manufacturer shall be latest ISO 9001 certified.

(2) All parts of the luminaires and associate equipment including installation shall be guaranteed by the Private Party at least two years after handover.

1.10.2 Materials

1.10.2.1 Description

(1) All luminaires shall be manufactured by a reputable lighting manufacturer.

(2) Luminaires shall be well constructed, shall comply with the requirements of IEC 60598-1, IEC 60598-2 and shall be chosen to suit the conditions under which they are to operate.

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

(4) All luminaires shall be free of light leaks, warps, dents, and other irregularities.

(5) The LED system shall be digitally driven using high-speed pulse width modulation (PWM) and noise shaping pulse width modulation (PWM) techniques. The LED system shall use integral and differential nonlinear control. Constant data transmission rated shall be employed, resulting in the output being independent of distance of cable between power supply and light source within the specified length. LED system shall have a selectable means of external control via a data network.

1.10.2.2 Component

(1) Luminaires (Lighting Fixtures), general

(a) Housing of the luminaire, generally, shall be made from high grade cold rolled steel sheet, 0.8 mm minimum thickness, and be provided with a lamp compatible with the control gear used. Any plastic used in the luminaires shall be UV and light stable and shall be suitable for their application. All sheet steel components shall be suitably pre-treated and painted using acrylic polyester or epoxy powders to prevent corrosion.

(b) The steel housing shall be grounded.

(c) All hangers, cables, supports, channels, frames and brackets of all kinds for safety erecting this equipment in place, shall be furnished and erected in place under this section. The luminaires shall be supported from the building structure and the hangers shall be adjustable in length.

(d) The LED luminaires shall be rated at 24 volts for colour changeable and 230 volts for static colour, 50 Hz. and operated at constant and carefully regulated current levels.

(e) For wet and damp use, LED-based luminaire itself shall be sealed, and test for appropriate environmental conditions, not accomplished by using an additional housing or enclosure. All hardwired connections to LED luminaires shall be reverse polarity protected and provide high voltage protection in the event connections are reversed or shorted during the installation process.

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

(g) The finish of exposed metal parts and stem lengths shall be as later directed by the Engineer's Representative, unless otherwise noted in the luminaire Schedule; trims for luminaires exposed to the weather shall have suitable gaskets.

(h) In the luminaires will use 105°C heat resistant cable for PVC cables with similar heat resistant sleeve and the connection size shall not be smaller than 1 sq.mm and shall be capable of conductivity not less than 125% of full load current.

(i) Reflectors & Louvers, if applied, shall be of anodized high purity aluminium with very low iridescence. The reflectors shall be parabolic shape and not be deformed by heat dissipated from the equipment within the luminaires. The louvers shall be diffuser type for reducing glare. The total reflectance shall be 87% as a minimum.

(j) Plastic diffuser, if applied, shall be made of high quality plastic with sufficient strength to withstand UV radiation heat within the luminaire and from the environment. The diffuser shall be designed for low brightness and glare free performance.

(2) High-bay Luminaires (if applied)

Where High-bay Luminaires are used, the luminaires shall consist of ballast housing and an optical assembly that shall be attached to the underneath of the ballast housing.

(a) The ballast housing shall be of die cast aluminium finished in epoxy grey enamel and shall contain all the electrical control gear including the choke, power factor correction capacitor and ignitor of a rating compatible with the lamp wattage. Where required, a standby electronic relay unit shall also be fitted into the housing to supply power to the emergency tungsten halogen lamp during the re striking period of the high pressure sodium lamp.

(b) A power factor correction capacitor complying with IEC 61048, IEC 61049 or other approved standard shall be provided to correct the power factor for each lamp to not less than 0.9 lagging.

(c) The optical assembly shall consist of a HID lamp of the approved wattage and a reflector. The reflector shall be open at the top and bottom to permit complete ventilation and thus a chimney effect to create a steady stream of air through the reflector, carrying direct particles out of the open top. A wire guard will also be provided at the bottom of the reflector, if required.

(d) The reflector shall be prismatic to provide effective control of the luminous flux to ensure freedom from glare at all normal viewing angles.

(e) A permanently spun on and sealed aluminium cover shall be provided on the external surface of the prismatic reflector.

(f) The luminaires shall be complete with suspension hook and safety chains to suspend the luminaires from the building structure in an approved manner. A plug and socket cable connector assembly arrangement shall be provided at the ballast housing to facilitate easy isolation of the luminaires from the incoming power cables during maintenance or replacement.

(3) Outdoor Luminaires (if applied)

(a) Outdoor luminaires shall be able to withstand the weather. Metal parts shall be bonded and protected against corrosion. The luminaire parts which have to be removed for access to the interior should have proper gasket to restrict the entrance of moisture and dirt. Stirrup mounting and similar parts shall be heavily galvanized, and bolts shall be made of stainless steel.

(b) The adjustment nuts and bolts of the luminaires that will be mounted on buildings or columns shall be captive to prevent loss or accident during servicing. Safety device shall be provided to prevent luminaires mounted at high position from dropping. The luminaires installed in such locations that are within hand reach shall be strongly constructed, fitted with an impact - resistant transparent or diffusing cover, and shall have secret key fixings for the cover to the body of the luminaires. Where necessary, wire guards shall be fitted over the cover to give extra protection.

(4) Lamps

(a) LED lamps

(i) The LED lamps shall have expected luminosity at 50,000 hours of not less than 70% of initial value (L70) when tested in accordance with IES LM-80 and IES Technical Memorandum 21 (TM-21).

(ii) The lamp shall have an initial luminous efficacy of not less than 100 lumens per watt after 100 burning hours (exclusive of circuit losses) at the rated voltage (220 V) and frequency (50 Hertz).

(iii) The color rendering index (CRI) shall not be less than 80 for indoor type luminaire and 70 for outdoor type luminaires or as approved at the detailed design stage.

(iv) The color temperature for LED shall be as follows:

- Daylight : 5,500 - 6,500 Kelvin
- Cool White : 4,000 Kelvin (within 3 Step McAdam)
- Warm White : 3,000 Kelvin (within 3 Step McAdam) or as specified on the type of luminaires.

(b) High Intensity Discharge lamps, such as high pressure sodium, metal halide, etc. (if applied) shall comply with IEC 62035, IEC 60662, and IEC 61167 respectively.

(5) Driver (Power/data supply) for LED

(a) Input Voltage : 230 V. ±10% 50 Hz.

(b) The driver shall have minimum life expectancy of 50,000 hours at maximum rated case temperature (Tcmax), separately packaged independently of LED module for better ventilation.

(c) The driver shall be fully functional at case temperature (TC) of not less than 70°C

(d) LED and driver shall be separately removable and serviced.

(e) The driver input current shall have total harmonic distortion (THDi) of not more than 15%.

(f) The driver shall have power factor at maximum load of not less than 0.95 (lagging).

(g) The driver shall have surge protection being capable of withstanding a voltage surge of not less than 2 kV (Line-Neutral).

(h) The driver shall complete with suitable protective devices to protect short circuit and over voltage.

(i) The driver shall pass appropriate electro-magnetic compatibility test.

(6) Ballasts for HID lamps (if applied)

(a) The ballasts shall be electromagnetic type, naturally cooled, high power factor (or low power factor with capacitor) complying with IEC 60923. Maximum winding temperature in ballast shall not exceed 130ºC.

(b) The ballasts shall be mounted in the fixtures or in separated weather-proof (IP55)

(7) Accessories

(a) Lamp-holders for tubular fluorescent lamps (or tubular LED lamps applied similar), if applied, shall be of non-flammable moulded, rotor-lock type and shall have silver plated or copper contacts. The lamp-holder shall comply with IEC 60400 or TIS 344 or equivalent.

(b) Lamp-holders for incandescent lamps and similar lamp caps, if applied, shall be porcelain type with a capacity suitable for applied lamps.

(c) Lamp-holders for HID lamps, if applied, shall be heavy duty porcelain mogul type, 600 V rating. The lamp-holders greater than or equal 500 watt shall be provided with ceramic cartridge fuse of appropriate rating for protection.

(d) Igniters for HID lamps, if applied, shall be electronic type with maximum output voltage of 750 V at an input voltage of 240 V, 50 Hz.

(e) Capacitors, to be equipped together with magnetic ballasts, shall comply with IEC 61048 and IEC 61049, and shall be dry type having sufficient capacitance to improve power factor to not less than 0.90 lagging. The capacitor terminals shall be snap-in type.

(f) Terminals, for wiring within the luminaires and for incoming wires, shall be snap-in type, silver-plated copper conductor and with 90°C (or higher) insulation.

(8) Emergency Lighting Luminaires or Emergency Lights (if applied)

The Emergency Lights shall comply with the aforementioned standards and the following requirements hereafter.

(a) The emergency lights shall be of the self-contained battery type suitable for a 240 V/1-phase 50 Hz system with 2 head LED lamps (light intensity not less than 2 x 55 Watt halogen lamps) and surface mounted.

(b) Each unit shall be equipped with the following equipment/devices (as a minimum):

(i) Maintenance free, sealed-lead acid battery for backup operating at least 2 hours

(ii) Solid state charger

(iii) Under and over voltage cut-off

(iv) Overload and short circuit protection

(v) Status indicating lamp for “Power On”, “Fully Charged”, “Charger Failure” & “Short Circuit”

(vi) Lamp & battery test button

(vii) Battery low level alarm (visible & audible)

(ix) Wireless remote testing

(c) Unit Housing: Corrosive-proof housing, fabricated from a 1.8 mm (minimum) sheet steel, finished with epoxy powder coating, and complete with battery basin. The housing shall be grounded.

(d) Electrical Connection: Power cord with molded plug; 2P+E 10 A. 250 V.ac

(e) The units, when installed in public areas, shall be concealed and the head lamps shall be separately installed (remote head lamps) at the locations as approved at the detailed design stage.

(8) Emergency Exit Signs (if applied)

The Emergency Exit Signs shall comply with the aforementioned standards and the following requirements hereafter.

(a) The emergency exit sign luminaires shall be of the self-contained battery type suitable for a 220 V/1-phase 50 Hz system with internally illuminated LED lamps, decorative design and surface-mounted type.

(b) Each unit shall be equipped with the following equipment/devices (as a minimum):

(i) Maintenance free, sealed-lead acid battery for backup operating at least 2 hours

(ii) Solid state charger

(iii) LED lamp and driver

(iv) Under and over voltage cut-off

(v) Overload and short circuit protection

(vi) Status indicating lamp for "Power On", "Charger Failure", "Battery Discharge"

(vii) Lamp & battery test button

(viii) Wireless remote testing

(c) Each of the Emergency Exit Sign shall comprise the white legend read "EXIT" with white icon of human escape and white directional arrow on green opal diffuser in accordance with EIT standard 2004-15.

(d) Unit Housing: Corrosive-proof housing, fabricated from a 1.6 mm (minimum) sheet steel, finished with epoxy powder coating, and complete with battery basin. The housing shall be grounded.

1.10.3 Execution

1.10.3.1 Installation

(1) The Private Party shall install the luminaires in accordance with approved Working Drawings and manufacturer's instructions. The installation shall comply with NFPA 70 and/or EIT Standard.

(2) Luminaires shall not be used as 'through boxes' for circuit wiring.

(3) All luminaires shall be adequately and rigidly supported in an approved manner. In all cases, all luminaires shall be suspended independently. The mounting height of the luminaires shall be as indicated on the approved drawings at the detailed design stage and as directed and agreed on site.

(4) Final connections to luminaires in areas where a suspended ceiling is provided shall be in a flexible conduit system.

1.10.3.2 Testing and Commissioning

(1) After the luminaires are completely installed, the wiring system, wiring and luminaires shall be tested against grounds and short circuit. Megger testing shall be conducted to all installed luminaires and control cables with phase-to-phase and phase-to-ground.

(2) The lighting system shall be checked at night to ensure that illumination levels as specified have been met.

(3) The performance of the luninaires and associate equipment shall be tested by powering-on all luminaries in a period of 24 hours, together with measuring of the illumination levels which should not be deviated.

1.11 SWITCH AND SOCKET OUTLET

1.11.1 General

1.11.1.1 General Requirement

(1) The Private Party shall furnish and install all lighting switches, socket outlets and their accessories as specified hereafter and as indicated on the approved drawings at the detailed design stage.

1.11.1.2 Standard and Reference

The switches and socket outlets shall comply with the following codes and standard.

(1)	IEC 60309-1	:	Plugs, socket-outlets and couplers for industrial purposes - Part 1: General requirements
(2)	IEC 60884-1	:	Plugs and socket-outlets for household and similar purposes - Part 1: General requirements
(3)	IEC 60669-1	:	Switches for household and similar fixed-electrical installations - Part 1: General requirements
(4)	IEC 60529	:	Degree of protection provided by enclosures (IP Code)
(5)	TIS 166-2549	:	Plugs and socket-outlets for household and similar purposes: Plug and socket-outlets with rated voltage not exceeding 250 V
(6)	TIS 824-2551	:	Switches for household and similar fixed electrical installations: General requirements
(7)	NFPA 70	:	National Electrical Code
(8)	EIT 2001-56	:	Thai Electrical Code 2013

1.11.1.3 Submittals

(1) The Private Party shall submit the installation details, material selection and catalogues to The Engineer's Representative for approval prior to proceed purchasing order.

1.11.1.4 Quality Assurance

(1) The equipment manufacturer shall be latest ISO 9001 certified.

(2) All parts of lighting switches and socket outlets including installation shall be guaranteed by the Private Party at least two years after handover.

1.11.2 Materials

1.11.2.1 Component

(1) Lighting Switches; general

(a) Description: General-duty rocker switch, toggle mechanism and comply with IEC 60669-1 and/or TIS 824-2551.

(b) Device body: White colored thermoplastic.

(c) Rated Voltage: ≥ 240 V.ac

(d) Rated Current: ≥ 15 Amperes.

(e) Faceplate: Metal plate (aluminium anodized / stainless steel / metal-clad heavy duty pattern as indicated on the approved drawings at the detailed design stage.

(f) Installation: Wall (or column) recessed/exposed.

(g) Switches located in wet and outdoor locations shall have to complete with the weatherproof cover plate and housed in a galvanized cast iron or impact resistance molded plastic enclosures providing the minimum degree of protection to IP 55.

(2) Socket Outlets (or Receptacles); general

(a) Description: General-duty receptacle, duplex universal pins 2P+E being used for both flat and round pins plug and completed with safety shutters, and shall comply with IEC 60884-1 and TIS 166-25413.

(b) Device body: White colored thermoplastic (red colored for UPS circuit, yellow colored for Essential circuit)

(c) Rated Voltage: ≥ 240 V.ac

(d) Rated Current: ≥ 15 Amperes.

(e) Faceplate: Metal plate (aluminium anodized / stainless steel / metal-clad heavy duty pattern as indicated on the approved drawings at the detailed design stage.

(f) Installation: Wall (or column) recessed/exposed.

(g) Socket outlets located in wet and outdoor locations shall have to complete with the weatherproof cover plate and housed in a galvanized cast iron or die-cast aluminium enclosures providing the minimum degree of protection to IP 65.

(3) Floor Mounted Socket Outlets (if applied)

(a) Description: The combination of floor recessed pop-up box and socket outlet. The outlet shall be a general-duty receptacle, duplex universal pins 2P+E being used for both flat and round pins plug and completed with safety shutters, and shall comply with IEC 60884-1 and TIS 166-25413.

(b) Device body: White colored thermoplastic (red colored for UPS circuit, yellow colored for Essential circuit)

(c) Rated Voltage: ≥ 240 V.ac

(d) Rated Current: ≥ 15 Amperes.

(e) Cover Plate: Stainless steel providing the minimum degree of protection to IP 54.

(4) Heavy Duty Power Outlets

(a) Description: Angle type heavy-duty receptacle, equipped with spring door cover with locked position to lock plug-in cord by simple twisting motion, and comply with IEC 60309-1.

(b) Protection Class: IP 44 for indoor and IP 67 for outdoor

(c) Installation: Wall/column exposed.

(d) Electrical Characteristic:

(i) 3P+N+E 415 V. /16 A., 32 A., 63 A.: as per the design at the detailed design stage.

(ii) 2P+E 240 V. / 16 A., 32 A. .: as per the design at the detailed design stage.

1.11.3 Execution

1.11.3.1 Installation

(1) The Private Party shall install the lighting switches, socket outlets and their accessories in accordance with approved Working Drawings and manufacturer’s instructions. The installation shall comply with NFPA 70 and/or EIT Standard.

(2) The maximum switch number placed at the same location, installed in the same box and covered by the cover plate, shall not be more than 3 gang switches.

(3) Only lighting switches connected to the same phase shall be allowed to mount on a common switch plate and adaptable box for 15A single-pole switch otherwise phase shall be physically separate within a switch box. Switch Normal and emergency lighting circuit shall be housed in a separated box.

(4) In general, the switches shall be installed at level 1,350 mm above the finished floor level unless otherwise approved by The Engineer's Representative.

(5) In general, the wall mounted socket outlets shall be installed at level 300 mm above the finished floor level unless otherwise approved by The Engineer's Representative.

1.12 LIGHTING CONTROL SYSTEM

1.12.1 General

1.12.1.1 General Requirement

(1) The Private Party shall furnish and install the lighting control system as specified hereafter and as indicated on the approved drawings at the detailed design stage.

(2) The Private Party shall base his tender on the system specified as the base offer. If alternative systems are proposed, they shall be listed as alternative offers. Divergences from these Specifications, which regarded as essential or as improvement shall be clearly pointed out and explained.

(3) The lighting control system configuration such as graphic, layout, setting and etc., shall be adjusted to harmonized with other lighting control system vendors applied in other phase of the project. The purpose is to establish a common configuration and standards enabling the operator to manage and operate the system efficiently. Such configuration shall be issued to the client or its representative for approval. This is also applied to third party vendors interfaces with the system.

1.12.1.2 Standard and Reference

(1) IEEE 802.2 : Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 2: Logical Link Control

(2) EN 50022 : Specification for low voltage switchgear and controlgear for industrial use. Mounting Rails. Top hat rails 35 mm wide for snap-on mounting of equipment

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

1.12.1.3 Submittals

(1) The Working Drawings, details of all material and equipment installations and programmable control schedules shall be submitted to the Engineer's Representative for approval prior to proceed purchasing order and installation sequentially.

(2) Operation and maintenance manuals of the system shall be prepared and submitted to the Engineer's Representative for approval before handover.

1.12.1.4 Quality Assurance

(1) The equipment manufacturer shall be latest ISO 9001 certified.

(2) All parts of the system including installation and its performance shall be guaranteed by the manufacturer and/or the Private Party at least two years after handover.

1.12.2 Materials

1.12.2.1 Description

(1) The lighting control system (LCS) shall be an intelligence network system, fully addressable, comprising microprocessor-based lighting control devices interconnected via a topology-free network that employs UTP-Cat.5e (or other high performance cable as recommended by the equipment manufacturer) to supply power under extra-low voltage (self-powered operations) and to facilitate communications between network devices.

(2) The system shall be capable of supporting 100 units of relay controller module (minimum) per single network and shall allow unlimited switching configurations.

(3) For future extension, the system components shall be able to be added or changed without interrupting the control cable or any other devices. No reconfiguration of existing units or network shall be required during any system reconfiguration. All existing units shall be removable without a system disturbance.

(4) In the event of power failure, non-volatile memory shall retain all programmed information relating to each unit's current operating status. The state of the lighting loads shall be able to be programmed to re-start to "on", "off" states or resume in previous state following mains power being restored after a power failure.

(5) Each individual switch (if applied) shall indicate the “On” and “Off” state of the controlled relay with an “On/Off” LED. Each switch shall be able to be programmed as toggle switch, scene or group function.

(6) The system shall be set-up for “fail-safe” operation such that under failure of control power, the emergency lighting shall start to “ON” state.

(7) Building Management System (BMS) shall be able to monitor and control all functions on the lighting control system via an interface unit.

1.12.2.2 Component

(1) Main control equipment

(a) The main control equipment comprises an interface unit for network recognition / distribution and PC Workstation equipped with licensed software for main control and monitoring of the system.

(b) PC Workstation

The Workstation shall be a complete set of desktop Personal Computer based on the latest technology about 3 months before the submission of technical documents in the approval stage (Vendor: Dell, HP, IBM or equivalent).

The following components and specifications (as stipulated below) are the minimum requirement for reference in the Bidding stage only.

(i)	CPU	:	64 bit Octa-Core (Intel® Core™ i7-6th Generation or equivalent) with clock rate up to 4.2 GHz per core and 8 MB Cache Memory.
(ii)	RAM	:	8 Gbytes / DDR4 / 2400 MHz.
(iii)	Display Adapters	:	Equipped with both On-board GPU and Separated Graphic Card on PCI Express Slot with 2 Gbytes / DDR5 GPU
(iv)	Hard Disk Drive	:	1,024 Gbytes / SATA 3 / 7200 RPM
(v)	Optical Disk Drive	:	8X - Multi-layer DVD-RW Drive
(vi)	Power Supply Unit	:	According to standard for Workstation
(vii)	Display Monitor	:	LED Monitor size 23”, 16:9 (or 16:10) Anti-glare Panel, QHD/1440p resolution, 75 Hz. Refresh rate

(viii) I/O interface ports comprise:

- D-Sub VGA port, HDMI port and UHD (4K) display port
- 2 ports of USB 2.0, 4 ports of USB 3.0 and Thunderbolt port
- Gigabit Ethernet (10/100/1000 Mbps) RJ45 port
- 3.5 mm ports for Audio IN/OUT
- Others according to Motherboard manufacturer

(ix) Peripheral devices comprise:

- Standard keyboard for English & Thai language (as the same brand of the Workstation)
- Five (5) buttons Optical Mouse (as the same brand of the Workstation).
- Others come with the Workstation according to Vendor's standard.

(c) Software

(i) Operating System (OS) : Windows 8.1 Professional 64 bit or better

(ii) Application Software : The licensed comprehensive software shall be provided from the system manufacturer. It shall be able to be configured easily for any control and monitoring functions as required and approved by the Engineer's Representative. Security login (Username & Password) for authorized Users/Operators shall be able to be edit by themselves.

(2) Relay controller unit (Sub controller)

(a) The unit shall be an addressable modular unit type, mounted on DIN rail according to EN 50022.

(b) The unit shall allow control of independent loads, equipped with a voltage-free magnetically latched relay per channel and shall support current rating up to 20 A per channel. All relay contacts shall be capable of carrying inductive lighting loads without derating factor.

(c) Non-volatile memory shall be equipped within the unit to retain all address setting and most recent information. All units shall be capable of stand-alone operation during the shutdown or failure of the main controller.

(d) Each unit shall have the feature for setting the manual-override functions onto Remote (ON/OFF) push-button switches. It shall be possible to connect these overrides in parallel to multiple units to allow manual-override of multiple units from one push-button location.

(e) Local ON/OFF push-button switches shall allow individual channels to be manually overridden on each unit.

(f) Logic states and relay interlocking features shall be selectable configured by the application software.

(3) Power supply unit

(a) The power supply unit shall be a modular type, mounted on DIN rail according to EN 50022.

(b) The unit, which transforms the input voltage at 230 V.ac to the required voltage for devices, shall have adequate power capacity for the connected equipment as designed on the detailed design stage and/or as recommended by the equipment manufacturer.

(4) Enclosure

(a) The enclosure, for installation of various device groups according to the detailed design, shall be cabinet with flush-key lock. The cabinets shall be fabricated from 2 mm (thickness) electro-galvanized steel sheet and coated with epoxy powder paint.

(b) The protection class of the enclosures shall comply with IEC 60529 and shall be categorized as follows:

(i) IP 31 for installation on dry and indoor locations.

(ii) IP 55 for installation on outdoor locations including wet areas.

(c) All enclosures shall be grounded.

(5) System Wiring

(a) The signal cables for wiring in the control system shall be a twisted pairs Cat.5e – FR (fire resistant) cable which is able to withstand on fire for 3 hours in accordance with IEC and/or BS standard, or as recommended from the system manufacturer but shall also have the characteristic of fire resistant material as stipulated.

(b) The cables shall be installed in conduit.

(c) Wiring method between the controllers shall be in accordance with the system manufacturer’s instruction.

1.12.3 Execution

1.12.3.1 Installation

(1) The Private Party shall install the lighting control system and accessories in accordance with approved Working Drawings and manufacturer’s instructions.

(2) All final connections, testing, adjustments and calibrations shall be made under the direct supervision of a factory-trained technician of the system supplier or as directed by the Engineer’s Representative.

1.12.3.2 Testing and Commissioning

(1) The system shall be tested to demonstrate that all wiring and equipment has been properly installed, and the system will function in the required manner.

(2) The Private Party shall conduct functional test and commissioning of the system which is complied with the manufacturing standards and requirements.

(3) The Private Party shall test the system to full function.

1.12.3.3 Training

(1) The Private Party shall prepare the approved instruction manuals for users.

(2) The Private Party shall provide training for the operators and maintenance staffs of the SRT to operate and maintenance the system by themselves.

1.13 EARTHING AND LIGHTNING PROTECTION SYSTEM

1.13.1 General

1.13.1.1 General Requirement

(1) The Private Party shall supply, install, connect, test and commission a complete system of the earthing and lightning protection as specified hereafter and as indicated on the approved drawings at the detailed design stage.

(2) All metal conduits, trunking and raceway systems, supports, cabinets, metal parts of switchgear, equipment cases, motor/generator frames, fuel tank, generator neutral, electrical fittings and fixed appliances liable to become live in the event of insulation failure, shall be effectively earthed by means of earth continuity conductors of adequate size.

1.13.1.2 Standard and Reference

(1) BS EN 13601 : Copper and copper alloys. Copper rod, bar and wire for general electrical purposes

(2)	BS EN 1982	:	Copper and copper alloys. Ingots and castings
(3)	BS EN 755	:	Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles
(4)	IEEE 837	:	Standard for Qualifying Permanent Connections Used in Substation Grounding
(5)	IEC 62305	:	Protection against lightning
(6)	UL 467	:	Grounding and Bonding Equipment
(7)	UL 486A-486B	:	Wire Connectors
(8)	UL 96	:	Lightning Protection Components
(9)	NFPA 70	:	National Electrical Code
(10)	NFPA 780	:	Standard for the Installation of Lightning Protection Systems
(11)	EIT 2001-56	:	Thai Electrical Code 2013

1.13.1.3 Submittals

As a minimum, the following shall be submitted to The Engineer's Representative for approval at the appropriate stages of the Works:

(1) Detailed schedule of equipment and components, manufacturer's data and samples.

(2) Design and calculations on the earthing systems.

(3) Detailed and coordinated working drawings on the routing of the earth termination network.

(4) Working drawings on the method of fixing and bonding of the lightning protection network.

(5) Proposed testing procedures and report format for testing of the earthing system.

1.13.1.4 Quality Assurance

(1) The equipment manufacturer shall be latest ISO 9001 certified.

(2) All materials and installation shall be guaranteed by the Private Party at least two years after handover.

1.13.2 Materials

1.13.2.1 Component

(1) Earthing and Bonding equipment

(a)	Steel Dowel Bar:	Comply with the standard for steel reinforcement used in the Building Structure. The number and size of the steel bars used shall be in accordance with the approved detailed design and calculation.
(b)	Galvanized steel flat bars:	Hot-dip galvanized complying with ASTM A123/ A123M. The cross sectional areas for the flat bars used for earthing network shall be in accordance with the approved detailed design and calculation.
(c)	Rod Electrode:	ø16mm (ø5/8 inch) x 3.05 m (10 feet) long, copper-clad steel with minimum coating thickness not less than 256 micron and comply with UL 467.
(d)	Inspection Pit (if applied):	Concrete pit with cover and available for the load up to 6000 kg.
(e)	Mechanical Connectors:	Copper alloy and comply with BS EN 1982.
(f)	Exothermic Connections:	High copper content alloy (≥ 93% purity), high corrosion resistance and comply with UL 467 or/and IEEE 837.
(g)	Earth Test Point:	Copper alloy complying with BS EN 1982, female type suitable for a bolt size such as M12, M16, M20, etc. in accordance with the approved detail design.
(h)	Conductor Wire:	Stranded bare copper wire complying with BS EN 13601 or/and UL 467.
(i)	Earth Bars:	Tin plated copper bars complying with BS EN 13601, complete with sufficient service holes made from the factory (drilling holes on site is not acceptable). Spare four (4) service holes for future connections shall be provided for each Earth Bar. Support for each earth bar shall be hot-dip galvanized steel with insulator and stainless steel bolts – nuts – washers.

(j) Test Boxes (if applied): Consist of Cast aluminium alloy box and lid complying with BS EN 755, Tin plated copper bar complying with BS EN 13601 and Insulators with stainless steel bolts, nuts and washers.

(k) Bolts, Nuts & Anchors: Stainless steel or Blass according to the equipment manufacturer's standard.

(2) Lightning Protection equipment

(a) Air Terminals: ø16mm (ø5/8 inch) x 0.60 m (2 feet) minimum length, sharp-tipped solid copper rod, and comply with UL 96. The length of the rod shall be in accordance with the approved detailed design.

(b) Air Terminals Base Supports: Copper alloy complying with BS EN 1982 or UL 96.

(c) Mesh Conductors on Roof: 25 x 3 mm^2 copper tapes complying with BS EN 13601 or UL 96.

(d) Conductor Supports: Copper alloy type with Blass bolts complying with BS EN 1982 or UL 96.

(e) Down Conductors: Stranded copper wires complying with BS EN 13601 or/and UL 467 or 25 x 3 mm^2 copper tapes as stipulated above or combination of the both types depending on the appropriate construction being designed on Working Drawings.

(f) Exothermic Connections: High copper content alloy (≥ 93% purity), high corrosion resistance, and comply with UL 467.

1.13.3 Execution

1.13.3.1 Installation

(1) The Private Party shall install the Earthing and Lightning Protection system in accordance with approved Working Drawings, manufacturer's instructions and the standard as specified.

(2) The earthing network on each level of each Station shall be arranged to emerge through the finished floor screed to a position clear from all reinforcement and to be agreed on site.

(3) Sharp bends in conductors shall be avoided.

(4) Where conductor will pass across the expansion joint of building structure, the tinned flexible copper braid with adequate sizes shall be required to be installed for linking between the conductors at both sides of the expansion joints.

(5) A permanent label durably marked with the words "Safety Electrical Connection – Do not Remove" in legible English and Thai lettering not less than 5mm high shall be permanently fixed in a visible position at or near the point of connection of every earthing conductors at the earth terminals, and the point of connection of every bonding conductor to extraneous conductive parts.

1.13.3.2 Testing and Commissioning

(1) The ground resistance, measured by the earth tester equipment, shall be not more than 5 ohms.

(2) Use suitable test instrument to measure resistance to ground of system. Perform testing in accordance with test instrument manufacturer's recommendations.

1.14 BUILDING MANAGEMENT SYSTEM (BMS)

1.14.1 General

1.14.1.1 General Requirement

(1) The Private Party shall furnish and install the Building Management System (BMS) as specified hereafter and as indicated on the approved drawings at the detailed design stage.

(2) The Building Management System (BMS) shall be supplied, installed, commission tested and maintained by a specialize Private Party who shall preferably be a control system supplier too.

(3) The Private Party is responsible for full coordination with sub-contractors for all works in connection with the installation of the BMS system.

(4) The Private Party shall base his tender on the system specified as the base offer. If alternative systems are proposed, they shall be listed as alternative offers. Divergences from these Specifications, which regarded as essential or as improvement shall be clearly pointed out and explained.

(5) The building management system configuration such as graphic, layout, setting and etc., shall be adjusted to harmonized with other BMS vendors applied in other phase of the project. The purpose is to establish a common

configuration and standards enabling the operator to manage and operate the system efficiently. Such configuration shall be issued to the client or it's representative for approval. This is also applied to third party vendors interfaces with the system.

1.14.1.2 Standard and Reference

The BMS system and its components shall comply with the following codes and standards.

(1) ANSI/ASHRAE Standard 135-2012 : A Data Communication Protocol for Building Automation and Control Networks

(2) ANSI/ASHRAE Standard 135.1-2013 : Method of Test for Conformance to BACnet«

(3) IEC 61000-6-3 : Electromagnetic compatibility (EMC) - Part 6-3: Generic standards - Emission standard for residential, commercial and light-industrial environments

(4) IEC 60950-1 : Information technology equipment - Safety - Part 1: General requirements

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

(6) IEEE 802.2 : Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 2: Logical Link Control

(7) NFPA 70 : National Electrical Code

(8) EIT 2001-56 : Thai Electrical Code 2013

1.14.1.3 Submittals

(1) The details of all material and equipment installations and programmable load control schedules shall be submitted to The Engineer's Representative for approval prior to proceed purchasing order and installation sequentially.

1.14.1.4 Quality Assurance

(1) The equipment manufacturer shall be latest ISO 9001 certified.

(2) All parts of the BMS including its performance shall be guaranteed by the manufacturer and/or the Private Party at least two years after handover.

1.14.2 Materials

1.14.2.1 Description

The BMS specified herein shall be capable of integrating building functions including equipment supervision, control alarm, energy management, and historical data collection and archiving. The BMS shall consist of the following equipment:

(1) One set of operator console, complete with color display monitor, keyboard and 2 sets of printers for normal and alarm conditions.

(2) Microprocessor based distributed controllers interface directly with sensors, actuators and environmental delivery systems, i.e. HVAC units, chiller electrical system, sanitary system etc.

(3) A two-wire loop communication network to allow data exchange between devices in the system.

(4) Pneumatic, electrical and electronic control sensors and actuators in accordance with the approved detailed design.

1.14.2.2 Component

(1) System Equipment

The system shall be of modular design in both hardware and software. The basis system element shall be interconnected by a multiplex communication network, which includes the following:

(a) PC Workstation

The Workstation shall be a complete set of desktop Personal Computer based on the latest technology about 3 months before the submission of technical documents in the approval stage (Vendor: Dell, HP, IBM or equivalent).

The following components and specifications (as stipulated below) are the minimum requirement for reference in the Bidding stage only.

(i) CPU : 64 bit Octa-Core (Intel® Core^{TM} i7-6th Generation or equivalent) with clock rate up to 4.2 GHz per core and 8 MB Cache Memory.

(ii) RAM : 8 Gbytes / DDR4 / 2400 MHz.

(iii) Display Adapters : Equipped with both On-board GPU and Separated Graphic Card on PCI Express Slot with 2 Gbytes / DDR5 GPU

(iv) Hard Disk Drive : 2,048 Gbytes / SATA 3 / 7200 RPM

(v) Optical Disk Drive : 8X - Multi-layer DVD-RW Drive

(vi) Power Supply Unit : According to standard for Workstation

(vii) Display Monitor : LED Monitor size 23”, 16:9 (or 16:10) Anti-glare Panel, QHD/1440p resolution, 75 Hz. Refresh rate

(viii) I/O interface ports comprise:

- D-Sub VGA port, HDMI port and UHD (4K) display port
- 2 ports of USB 2.0, 4 ports of USB 3.0 and Thunderbolt port
- Gigabit Ethernet (10/100/1000 Mbps) RJ45 port
- 3.5 mm ports for Audio IN/OUT
- Serial ports dedicated solely to BMS network communications and receipt of alarms from the BMS system.
- Others according to Motherboard manufacturer

(ix) Peripheral devices comprise:

- Standard keyboard for English & Thai language (as the same brand of the Workstation)
- Five (5) buttons Optical Mouse (as the same brand of the Workstation).
- Others come with the Workstation according to Vendor's standard.

(b) Report Printers

The Printers, to be provided for recording alarms operator transactions and system reports, comprise:

(i) 24 Pins Dot-matrix Printer with at least a “paper width and have 160 characters per second capacity. Supply one box of 2000 sheets of printer paper and two (2) printer ribbon or cartridges.

(ii) Color Printer (inkjet) – 1200 x 1200 dpi using an A4 medium, 12 sheet/minutes (at 600 dpi B&W).

(c) Remote Processing Unit (RPU)

(i) The RPU shall be microprocessor based design for performing control, alarm and monitoring programs.

(ii) The RPU shall capable of control on-off command, mode change, status input and digital alarms etc. The RPU shall also include energy management program for time of the day program, optimum start/stop and duty cycling, etc.

(iii) RPU shall be installed in electrical room or mechanical room or as specified in the drawing. It shall be possible to expand each RPU by additional input/output modules.

(iv) The RPU shall accept the following type of inputs and outputs.

Input	Output
Analog 4 – 20 mA Dry contact (NO or NC) Pulse accumulator Override switch Photocell contact Transducer sensors Etc.	Analog 4 – 20 mA Dry contact (NO or NC), 20A, 250V Momentary-pulsed and Mechanically latched

(v) If the CPU transmission network fails but power to RPU does not, the RPU shall continue to monitor all changes of state or value and shall retain the most recent values; the RPU shall also maintain all analog set points and command positions.

(d) Sensors and operating equipment

The Private Party shall supply the sensors, transmitters and relays necessary for the BMS system.

For voltage, current and kW measurements, the Private Party shall provide the transformers with standard outputs.

(i) Filter pressure drop of each filter bank, if applied in the points schedule, shall be sensed by means of a diff. pressure sensing device which closed a contact when the filter pressure differential exceeds a typical pressure.

(ii) Low Temperature Limit Thermostats, if applied or described in the sequences of operation, install low temperature limit thermostats complete with 6.1 m. {20 ft.} of sensing capillary sensitive to 406 mm. {16”} and shall have manual reset provide one limit thermostat for approximately every 6 m^2 [65 sq.ft.] of duct area.

(iii) High Temperature Limit Thermostats, if applied, for individual systems provide high limit thermostats to shut down respective fan system (S). Provide a single rod and tube type manual reset limit thermostat set a 57.5 ^{O}C.

(iv) Air proving switches, if applied, shall utilize a differential pressure activated, diaphragm actuated, snap-acting SPDT switch rated at 13.8 A; 120/1/60 AC full load.

(v) Air flow for each AHU as specified herein, if applied, shall be indicated by means of a diff. Pressure sensing device which shall open a contact when the pressure is different. All fans shall use diff. pressure sensor or AUX. contact for start/stop indications, pressure of air flow falls below a typical value. Pressure transmitters shall be suitable for continuous contact with the material being measured (i.e. air, water glycol, or steam as applicable).

(vi) Pressure transmitters, if applied, shall have a linear output of 0-10V. Pressure transmitters shall be a span of not greater than twice the static pressure at maximum flow or differential pressure at shutoff as applicable.

(vii) Water flow for pumps, if applied, shall be indicated by means of diff. pressure or flow switches which open a contact as the diff. pressure or flow falls below a typical value. Water flow switches shall have a paddle actuated; snap-acting SPDT switch rated at 16 A; 120/1/60 AC full load.

(viii) Humidity sensors, if applied, shall be suitable for operating ranges of 10 to 100% RH and shall incorporate a solid state sensing element. Sensor accuracy shall be ±3% over a range of 5 to 95% RH. Humidity sensors shall also incorporate a transducing circuit for conversion of the sensed variable to a voltage level for digital conversion.

(ix) Carbon dioxide sensors for air quality control purposes, if applied, shall have the following characteristics.

1) Measurement Range - 0 - 2000 ppm CO_2

2) Accuracy ± 50 ppm

3) Repeatability ± ppm

4) Drift ± ppm per year

5) Output Signal 0-10 VDC proportional over the 0-2000 on range.

6) Response time 20 seconds maximum.

7) Operating conditions 0-50^{o}C, 10-100% RH non-condensing

8) Provide one single point calibration kit.

(x) Water-flow measuring devices (if applied) consisting of annular averaging pilot tube flow elements having the following minimum Specifications. Select the Annular for the operating flow range, pipe size and fluid temperature.

1) Accuracy - ± 2%

2) Repeatability - ± 1.2%

3) Pressure Drop - 1.5 kPa maximum

4) Operating Temperature Range – 4^{o}C to 95^{o}C [140^{o}F to 203^{o}F]

5) Operating Pressure Rating - 174 kPa [250 psig]

Provide weld couples for installation by the heating Private Party. Provide Model 1440, 25 mm. [1”] carbon steel coupling with MPE stainless steel cap for future Annubar corrections. Install the annubar flow device in accordance with the manufacturer’s recommendations and located with sufficient upstream and downstream straight pipe without obstructions.

(xi) Pressure sensing elements, if applied, shall be bourdon tube, bellows or diaphragm type. Adjustable set-point and differential. Pressure switches shall be snap action type rated at 220 volts, 10 amp AC or 24 volts DC.

(xii) Temperature sensing element, if applied, shall be liquid, vapour or bimetallic type. Supply adjustable setpoint and differential. Snap action type rated at 220 volts, 10 amps or 24 volts DC as required. Sensors shall operate automatically and reset automatically.

Temperature switches shall be of the following types.

1) Room type shall be suitable for wall mounting on standard electrical box with or without protective guard.

2) General purpose duct type shall be suitable for insertion into air ducts, insertion length of 450 mm. [18”].

3) Thermowell type shall be complete with compression fitting for 20 mm. [0.8”] NPT well mounting of length of 100 m. [4”]. Immersion wells shall be stainless steel.

4) Strap-on type shall be complete with helical screw stainless steel clamps.

(xiii) Transducers for kW, current, voltage, pressure, etc. (if applied) shall be of industrial standard with linear output of 0 or 4-20 mA. The transducer shall be potential free.

(xiv) Pulse kWH meter for monitoring of the electrical consumption, if applied, shall be of an electronic type with impulse output acceptable by RPU.

(xv) Start/stop relay modules shall if possible provide either momentary or maintained switch actions as appropriate for the unit being started and depending on the fact whether the units are subjected to a power fail restart program or not. All relays shall be mounted in interface panels and/or starter panels.

(xvi) All control point requiring remote adjustments shall be provided normally with control devices that will hold the last requested output regardless of CPU malfunction or power failure to control panel unless it is specified otherwise in the control specs.

(e) Control Cable and Cable Connection

Type of cable shall be as per manufacturer or recommendations as follows:

(i) Multi-core with shielded cable or as approved at detailed design stage shall be used between CPU and RPU.

(ii) Twisted pair with aluminum shielded cable shall be used between RPU and Marshaling Box (for analogue signal).

(iii) CVV cable or as specified on the Drawings shall be used between RPU and MS (for digital signal).

(iv) Male and female connector shall be provided for RL bus.

(v) Terminal blocks shall be provided in panel for RPUs to load points.

(vi) If screen is required, aluminum tape laid longitudinally and in contact with the un-insulated drain wire or un-insulated circuit protective conductor (cpc) shall be provided.

All field control wiring associated with analogue inputs/outputs shall be run in screened cable with a minimum cross sectional areas of 0.5 mm^2.

All field control wiring associated with digital inputs/outputs shall be wired in unscreened cable with a minimum cross sectional areas of 1.0 mm^2.

All field control wiring shall be wired contained in trunking or conduits.

All field control wiring for equipment used for life safety shall be of fire resistant cable.

(2) System Software

(a) The Main Software

The software shall include, as a minimum, the operation system (MS-DOS together with Microsoft Window 7 or 8.1), Communications and Alarm Handlers, Schematics and Text display handlers, Graphs and Automatic Reporting, Calendars, Work Processing, Computer Aided Drawing and Spreadsheet Programs.

(b) Operator Interface Software

All operator interaction with the system shall be via the mouse. Moving from one item to another shall be accomplished without the operator having to learn any codes, abbreviations, syntax or point addresses, and without having to use the keyboard. Information shall be displayed in screen “windows” and it shall be possible to have a large number of windows open at any time, limited only by the size of the screen. The software shall consist of number of separate programs:

(i) ***Password Protection:*** Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display and database manipulation capabilities as he deems appropriate for each user, based upon an assigned password.

A minimum of five levels of access shall be supported:

Level 1 = Date Access and Display

Level 2 = Level 1 + Operator Overrides

Level 3 = Level 2 + Database Modifications

Level 4 = Level 3 + Database Generation

Level 5 = Level 4 + Password Add/Modification

A minimum of 50 passwords shall be supported for the system.

Operators will be able to perform only those commands available for their respective passwords. Menu selections displayed at any operator device, including portable or panel mounted shall be limited to only those items defined for the access level of the password used to log-on.

User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices online.

(ii) ***Schematic Pictures:*** The schematics program shall allow data from the BMS controllers to be displayed together with a schematic drawing of the building. The data points shall be positioned anywhere on the drawing and shall be displayed either as an analogue value or digital values. The schematic drawings shall contain “Click Boxes” to enable the operator to move from one drawing to another or to select some other function merely by pointing to the click box and pressing the mouse button. The functions selectable by this means shall include:

1) Selecting another schematic drawing

2) Adjustment of a value, e.g. a setpoint

3) Select and display a graph or user page, either full size or as a “Pop-up” window on top of the current window.

4) Run another program, including proprietary software unconnected with the function of the main supervisory software.

5) Etc. Click boxes shall be user-definable.

(iii) ***Computer Aided Drawing (CAD):*** The software package shall include a CAD program which shall be used to create schematic drawings for use in the schematics program.

(iv) ***User Pages:*** The User Page program shall provide the means to display data as a list of text, where this form of display would be more appropriate than a schematic picture. Data shall be displayed as specified for the schematic program. It shall be possible to display data from any combination of controllers in the system, including RPU. Foreground and background colours shall be operator selectable. Data values which are in an alarm condition shall be displayed in a complementary colour to highlight this condition. All text and data displayed in a user page shall have the facility to be copied and included in a document being processed by a different application, e.g. a word processing program.

It shall be possible to use click boxes in user pages exactly as specified for the schematic program.

(v) ***Graphs:*** The graphs program shall allow the display and printing of trend logs held in the RPU. Up to four traces shall be displayed simultaneously on the same axes. Each trace shall have a different, user definable, colour and shall print out using a different line style (and different colour where a colour printer is used). The points to be displayed shall be on-line selectable and the graph may be displayed in real time, or the definitions may be saved on disk and recalled whenever required. Graph definitions which have been saved on disk shall be displayed from a schematic drawing or a user page by means of a click box, as previously specified. Historic graphs may be concentrated to show a series of logs on a single pair of axes.

(vi) ***Automatic Reporting:*** This program shall permit historical data to be built up in any of the display modes, i.e. Schematics, User Pages or Graphs. In Record mode the program shall automatically collect data at operator defined intervals and in the selected display mode, and shall save the data on disk for later recall. The data shall be collected automatically as a background task and shall require no operator intervention, other than to start it running. It shall be possible to play back the recorded data at any time simply by specifying the time and date of the recorded data to be viewed.

(vii) ***Alarm Handling:*** Any incoming alarm message regardless of type shall be displayed in a "Pop-up" panel on top of whatever is currently displayed on screen. Each alarm panel shall have a user-assigned title indicating its source or function, and shall flash to attract the operator's attention. All incoming alarms shall have the option of being printed and logged on disk. An optional audible signal shall also be provided, which shall continue to sound until the alarm has been acknowledged. Under normal operating conditions it shall be possible for an alarm condition to appear on screen less than 5 seconds after it occurs.

(viii) ***Calendars:*** This program shall provide the facility to link outstation time zones to supervisor calendars which may be used by the operator to set occupation times. The program shall provide the facility to set up special days, i.e. days on which the occupation times are different to the normal schedule, up to one year in advance.

(ix) ***Dynamic Data Exchange:*** The Supervisor software shall be written to the Microsoft Windows standard and shall fully support the inter-program data exchange protocol known as Dynamic Data Exchange (DDE).

(c) Control RPU Software

(i) ***General:*** The RPU shall be capable of fully stand-alone operation and shall be independent of any central computer for all specified control or communication applications. The software shall include all necessary routines and modules required to implement any control strategy and shall be user programmable. The programming language shall be English and shall use standard controls terminology.

(ii) The RPU operating software shall be held in a minimum of 120 kBytes of EPROM and shall operate in real time. Control strategies shall be held in a minimum of 32 kBytes of RAM which shall be battery backed up for at least two years. The software shall include a continuous self-test routine which shall test all parts of the main processing unit and shall report any failures to the main supervisor.

(iii) Input and Output point processing shall include:

1) Continuous update of input and output values, conditions and status. All connected points are to be updated at a maximum of 5 second intervals.

2) Analog to digital conversion of input values shall be carried out with at least 11 bit resolution with typically 40 dB series mode rejection @50 Hz. It shall be possible to calibrate the inputs by means of movable jumpers or links to suit the sensor type in use, to achieve a high accuracy reading.

3) Input reading shall be automatically checked to determine that the reading is within the sensor's range and within the range of the input circuit, i.e. 0-10V or 4-20mA. Should this not be the case then an alarm status shall be indicated.

User-defined units, normally recognized engineering units.

4) All sensor readings shall be in engineering or user-definable units. These units shall be calculated by the sensor scaling type assigned to each sensor.

5) Each sensor shall have, in addition to the checks specified above, operator adjustable High and Low alarm limits. If the sensor reading is outside these limits then an alarm shall be generated. It shall be possible to delay these alarms by a user-defined amount so that spurious alarms are not reported.

6) Up to 40 logging channels shall be provided per controller with 96 points per channel. Each logging channels points shall be recorded at user selectable intervals of 1 minutes, 15 minutes, 1 hour or 24 hours.

7) All digital inputs shall be de-bounced and shall be capable of receiving pulses at a maximum rate of 30 Hz.

8) All inputs shall be filtered to reject mains frequency interference. The mains frequency of 50 Hz shall be selectable in software.

(iv) All output points shall have optional start up delays assigned which shall prevent all plant from starting at the same time. These delays shall be adjustable by the operator.

(v) Alarms shall be provided with user-adjustable delays to prevent nuisance alarms. A log of the last 32 alarms shall be stored in the controller.

(vi) Provision shall be made to count the total running hours of any digital input or output and to assign an operator-definable limit to this period. Provision shall be made to generate an alarm if any plant item exceeds its defined run time limit.

(vii) Provision shall be made to count the number of starts for any plant item. Limits shall be assignable and an alarm shall be generated if the limits are exceeded.

(viii) Each RPU is to be configured to run the control strategies called for in the sequence of operation sections of this specification. Each RPU shall have the required software modules available for arithmetic calculations, logical decisions and relational operators necessary for the implementation of these control sequences.

1) RPU data such as set points, sensor values, loop parameters etc., shall be available to the operator for display and modification at the main supervisor, the portable supervisor or the display panel.

2) The reschedule time of control loops shall be adjustable, in 5 second intervals.

(ix) Each RPU shall provide five independent time zones, each of which shall have three separate start/stop periods within each 24 hours.

1) Unique time program shall be provided for each day of the week, plus a unique holiday schedule. Each RPU time zone may be provided with unique time programs, or they may be grouped and assigned a common time program as configured by the operator.

2) For each time program, the main supervisor shall have a calendar available which may be used to make simple modifications up to a year in advance. The calendar shall allow these modifications to be permanent or to execute

only once and then return to the previous (permanent) schedule.

3) Calendar days which are intended to operate as Holidays shall also be definable up to a year in advance.

(x) All control strategies shall be held in RAM, battery backed up for at least 2 years. All data shall be available for review and modification from the main or portable supervisors.

(d) Program Application

(i) Optimum Start/Stop: OS

The automatic system shall include a software program to perform optimized start up and shutdown of selected equipment. The program shall start HVAC equipment at the latest possible time to achieve the desired zone conditions by occupancy of time, and also shutdown HVAC equipment at the earliest possible time before the end of the occupancy period, and still maintain desired comfort conditions.

(ii) Time Program: TP

A comprehensive program shall be provided to automatically start/stop designated points according to a stored time, it shall be possible to individually command a point or group of points. It shall be possible to assign variable time delays between each successive start/stop command within that group.

(iii) Peak Demand: PD

The automation system shall include a software program to perform Peak Demand Limit. The program shall monitor the rate of electrical power consumption and forecast the total demand during each demand interval. If the predicted demand exceeds demand limit, the program shall automatically sheds loads to reduce demand.

(iv) Run Time: RT

The automation system shall include a software program to perform log run time totalization of selected equipment and shall include user name (s) and associated totalized values.

(v) Alarm Limit: AL

For analog point which shall have associated high/low limits, if the measured or calculated values drops below the low limit or exceed the high limit, that point shall be considered in alarm and report as previously defined in alarm reporting.

(vi) Historical Trend Log: HL

The operator shall be able to assign any system point, analog or binary, real or calculated to a trend group. Trend groups shall consist of a single point or multiple point groups with capacity of at least 50 points. Trended values shall be historically retained on the system for future inquiry.

(vii) Graphic Monitor: GM

The automation system shall include a software program to show the system diagram, floor plan lay-out with equipment and alarm points.

(viii) Alarm Report: AR

Each alarm as determined by the system shall cause the following information to be logged.

1) current time, date and initial of on-duty operator
2) point/type of alarm
3) current valve or status
4) operator instructive message
5) etc.

(ix) Maintenance Manage: MM

Maintenance Manage schedules maintenance activity on a calendar, run-time, and even-occurrence basic. It issues detail work orders, tracks material inventory, and provide work orders and schedule maintenance through conversational menus and prompts.

Note: The program application shown above is the minimum requirement; it might be changed/added later by The Engineer's Representative and manufacturer's recommendation.

(3) BMS Control and Communication Protocol

International standard open system protocol such as BACnet, Lontalk, ARCNET and etc. shall be used for BMS control and communication.

(4) Network Architecture interfacing

(a) The inherent extensibility of the product architecture allows third parties to add functionality into the product at LAN level in the station. This will allow functions not originally intended to be in the product, to be integrated at a fundamental level and appear as a part of the platform.

(b) BMS is extensible in a number of ways, including:

(i) Components can be added to the system (this includes server modules and their associated interfaces).

(ii) Data can be easily imported into SCADA from BMS.

(iii) Many aspects of BMS provide software interfaces, allowing BMS to be a component in a larger system.

(c) The SCADA system information is accessible from BMS by external systems via standard technologies.

(d) Primary methods of accessibility include:

(i) All real-time data is available via Object Process Control(OPC) including raw RPU values, calculated values, alarm counts, alarm status etc.

(ii) Real-time data may be exported also using Object Linking and Embedding (OLE) - Online Database Connectivity (ODBC).

(iii) Internal object model COM provided.

(iv) All historical data is available via OLE-ODBC.

(v) Possible support for other OPC specifications, including Alarms and Events, Security and Historical Data Access.

1.14.3 Execution

1.14.3.1 Installation

(1) All equipment and accessories shall be installed in accordance with the manufacturer’s recommendation and as specified on the approved Working Drawings.

1.14.3.2 Testing and Commissioning

(1) The BMS system is subject to the following test:

(a) Operational test of the system.

(b) Operational test of the RPU.

(c) Monitoring system.

(d) Others as specified by Manufacturer and The Engineer's Representative.

1.15 SCADA INTERFACING SYSTEM

1.15.1 General

1.15.1.1 General Requirement

(1) The Private Party shall furnish and install the SCADA Interfacing system as specified hereafter and as indicated on the approved drawings at the detailed design stage.

1.15.1.2 Standard and Reference

(1)	IEC 60947-7-1	:	Low-voltage switchgear and controlgear - Part 7-1: Ancillary equipment - Terminal blocks for copper conductors
(2)	IEC 60529	:	Degree of protection provided by enclosures (IP Code)
(3)	NFPA 70	:	National Electrical Code
(4)	EIT 2001-56	:	Thai Electrical Code 2013

1.15.1.3 Submittals

(1) The details of all material and equipment installations shall be submitted to The Engineer's Representative for approval before giving the manufacturer a purchase order and installation.

1.15.1.4 Quality Assurance

(1) The equipment manufacturer shall be ISO 9001 certified.

(2) All parts of the system including its performance shall be guaranteed by the manufacturer and/or the Private Party at least two years after handover.

1.15.2 Materials

1.15.2.1 Description

The SCADA interfacing consists of Marshaling Cabinet (MS-00) located adjacent to RTU in communication room, sub marshaling cabinets (MS-XX) are located adjacent to devices or equipment in all areas and MS-00 shall be connected to each MS-XX by hard wires cables via conduits or cable trays as specified on the approved detail design:

1.15.2.2 Component

(1) Marshaling Cabinets (MS)

(a) The terminal blocks shall be provided for termination of all SCADA interface monitor /control signal wiring. Terminal blocks shall be designed and tested in complying with IEC 60947-7-1. Terminal block shall have ability to receive unprepared conductors.

(b) Terminal block shall be single terminal type. Each terminal shall be exchangeable without dismounting adjacent terminals and also suitable for designative labeling.

(c) Terminal blocks shall be of the rail-mounted type and shall be of screwless type terminals 600 V.ac. moulded block type with molded insulating barrier between terminals. Terminal connections shall be such that the conductors shall be connected with the necessary maintained contact pressure. Terminals shall be so constructed that the conductors can be clamped between suitable surface without any significant damage either to conductors or terminals.

(d) Terminal blocks shall have test probe facilities for connections of test leads and an integral disconnecting device to facilitate testing.

(e) The rated cross-section of a terminal block shall be 0.5-2.5 mm^2 of round copper conductor. No terminal can carry more two conductors simultaneously connectable on each incoming/outgoing side.

(f) The terminating block in all the MS shall be spare capacity at least 20% of the number of I/O points.

(g) The MS shall be fabricated from 1.6 mm (minimum) thick galvanized sheet steel with gray colored epoxy electrostatic powder coated. The protection class shall be IP 31.

(2) SCADA Interfacing Cables

(a) Digital input (DI) and Digital output (DO) signals shall be used multi-core CVV cables via conduits or wireways.

(b) Analog input (AI) and Analog output (AO) signals shall be used twisted pair with aluminum shield cables via conduits or wireways.

(c) SCADA interfacing cables, for life safety lifts, fire alarm system and fire pumps, shall be FR cable in compliance with BS 6387 category CWZ (or other approved standard) via conduits only.

(d) The numbers of SCADA interfacing cable shall be spare capacity at least 20% of the number of I/O points.

(3) Field Control Wiring

(a) If screen is required, aluminum tape laid longitudinally and in contact with the un-insulated drain wire or un-insulated circuit protective conductor (cpc) shall be provided.

(b) All field control wiring associated with analogue inputs/outputs shall be run in screened cable with a minimum cross sectional areas of 0.5 mm^2.

(c) All field control wiring associated with digital inputs/outputs shall be wired in unscreened cable with a minimum cross sectional areas of 1.0 mm^2.

(d) All field control wiring shall be wired contained in trunking or conduits.

(e) All field control wiring for equipment used for life safety shall be of fire resistant cable.

1.15.3 Execution

1.15.3.1 Installation

(1) All equipment and accessories shall be installed in accordance with the manufacturer's recommendation and as specified on the approved Working Drawings.

1.15.3.2 Testing and Commissioning

(1) The Private Party shall test the system to full function.

(2) The Private Party shall prepare instruction manual of the system for users.

(3) The Private Party shall provide training to maintenance staffs covering the function and maintenance.

1.16 FIRE ALARM SYSTEM

1.16.1 General

1.16.1.1 General Requirement

(1) The fire alarm system shall be fully analog addressable, pre-signal, non-coded system in accordance with NFPA and shall be in compliance with UL listed and FM approved.

(2) The Private Party shall furnish and install the fire alarm system and equipment as specified hereafter and as indicated on the approved drawings at the detailed design stage.

1.16.1.2 Standard and Reference

The fire alarm system shall comply with the following codes and standards.

(1) NFPA 72 : National Fire Alarm Code

(2) NFPA 70 : National Electrical Code

(3) UL 38 : Manual Signaling Boxes for Fire Alarm Systems

(4) UL 268 : Smoke Detectors for Fire Alarm Systems

(5) UL 268A : Smoke Detectors for Duct Application

(6) UL 464 : Audible Signal Appliances

(7) UL 521 : Heat Detectors for Fire Protective Signaling Systems

(8) UL 864 : Control Units and Accessories for Fire Alarm Systems

(9) UL 1638 : Visual Signaling Appliances - Private Mode Emergency and General Utility Signaling

(10) UL 1971 : Signaling Devices for Hearing Impaired

(11) Factory Mutual (FM)

(12) IEC 60331 : Tests for electric cables under fire conditions - Circuit integrity

(13) IEC 60332 : Tests on electric and optical fibre cables under fire conditions

(14) IEC 61034-2 : Measurement of smoke density of cables burning under defined conditions - Part 2: Test procedure and requirements

(15) IEC 60754-2 : Test on gases evolved during combustion of materials from cables – Part 2: Determination of acidity (by pH measurement) and conductivity

(16) BS 6387 : Test method for resistance to fire of cables required to maintain circuit integrity under fire conditions

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

(18) NEMA ANSI C80.6 : Electrical intermediate metal conduit (IMC)

1.16.1.3 Submittals

(1) The material lists and technical data, Working Drawings, details of all material and equipment installations, and control logic shall be submitted to the Engineer's Representative for approval before giving the manufacturer a purchase order and installation.

1.16.1.4 Quality Assurance

(1) The equipment manufacturer shall be latest ISO 9001 certified.

(2) All parts of the system including its performance shall be guaranteed by the manufacturer and/or the Private Party at least two years after handover.

1.16.2 Materials

1.16.2.1 Description

(1) The fire alarm system shall be a fully analog addressable system whereby detection and alarm call points are loop-wired, giving fully analog output signals representing the true values of sensed phenomena to the control panel which incorporates intelligence, to make the decision of fire (or fault) based upon the analog information received.

(2) The system shall be electrically supervised for all initiating signal circuits, alarm notification signal circuits and power supply circuits.

(3) The addressable loops connecting addressable detectors, monitor modules, control modules, output modules, relay modules and line isolators to the fire control panel shall be wired in loops to form "Class A" or full duplex configuration. Line isolators shall be provided to isolate damaged parts of the cable loop and reduce to two wire half-duplex configuration when one of the paths has failed.

(4) Wiring from initiating devices (manual stations) and alarm notification devices to modules shall be wired in form of a "Class A" (4 wires).

(5) The fire alarm system shall be able to interface the following other system:

(a) Firefighting water flow alarm switches (for monitoring of activated status).

(b) Firefighting supervisory switches (for monitoring of activated status).

(c) Escalator Sprinkler Protection Systems; ESPS (for monitoring of alarm activated status).

(d) FM200 agent fire suppression systems (for monitoring of alarm activated status).

(e) Deluge pre-action system (for monitoring of alarm activated status).

(f) Diesel engine and electric fire pump control panels (for monitoring of activated status).

(g) Lifts/Escalators (for sending the evacuation signal to lift/escalator control panels for shutting down the operation in the event of evacuation).

(h) Building Management System; BMS (for sending the system status and alarm signals to BMS for monitoring).

(i) SCADA (for sending the system status and alarm signals to SCADA for monitoring at Operation Control Center; OCC).

(j) Station centralized master clock system (for synchronization of Date & Time).

(k) Automatic Fare Collection System; AFC (for sending the evacuation signal to the system).

(l) Public Address System (for sending the evacuation signal to the system).

1.16.2.2 Component

(1) *Fire Alarm Control Panel (FCP)*

(a) The fire alarm control panel shall be fully analog addressable, microprocessor based with provisions for monitoring addressable devices using plug-in zone P.C.B. cards, complete with power supply, battery and charger. The panel shall be a dead-front, heavy gauge steel enclosure, console type.

(b) The control panel shall have as a minimum 8 bit microprocessor base controlled by a program written in EPROM and shall be capable of receiving information from the detection devices such that each device can be uniquely identified and its alarm/non alarm state monitored.

(c) The approval standard of the control panel shall be UL 864 listed and FM approved.

(d) The following (LED) indicators and control switches shall be provided on the panel:

(i) Indicators:

- System ON
- System Fault/Failed
- Battery ON
- Alarm Condition
- Trouble Condition

(ii) Control switch:

- Reset
- Alarm acknowledge
- Alarm silence
- Trouble silence
- General alarm (evacuation)
- Lamp test

(e) The panel shall contain an integral back-lit LCD display which is visible through the panel door.

(f) The LCD display and printer programming shall be accomplished on-site by means of a handheld computerized device that shall plug into the panel.

(g) Programming functions shall include alarm/trouble type assignment, point descriptor assignment and alarm message assignment. Data files for the LCD display shall be stored in EPROM.

(h) The panel shall monitor the links with all detectors and sensors continuously. Upon actuation of one of the detectors or sensors, the LCD display shall indicate the ID number of the activated device, the appropriate status, the current time and date and the appropriate massage within the beginning of display lines. An alarm with buzzer and flashing LED shall be activated until acknowledged. The loss or failure of any device or sounder shall be identified and presented as a fault within 60 seconds.

(i) The FCP shall incorporate indicator lamps covering system fault, device fault, external fault, processor fault and device isolated.

(j) Actuation of one sensor in a loop should not cause the loop to be disabled for a late coming alarm signal from other sensors. If a next alarm is queuing, a "Next Alarm" LED should be lit on the panel and can be displayed on the display by pressing the "acknowledge" switch. However, the appropriate LED on the graphic annunciator panel shall flash once the alarm is received.

(k) The number of current fire alarms, unacknowledged alarms, trouble conditions and other miscellaneous alarms in the system shall be indicated in the end display line of the LCD display and a hard copy printed out from the printer. Text in English will be required.

(l) The status of the smoke and heat detectors shall be indicated on the panel showing the alarm condition and the area where the detector is located. A pre-alarm signal shall be generated for warning purposes if the detector condition deteriorates.

(m) Adequate communication ports and auxiliary contacts shall be provided with the FCP for interfacing with other system as listed in item 13.16.2.2 (5) (h) to (l).

(2) *Annunciator Panel*

(a) The annunciator panel shall be of the surface mounted panel board with graphic representation of the location or zone of fire upon operation of a manual or automatic detector.

(b) The panel shall be fabricated from stainless steel sheets in standard frame dimension of A1 paper (840 (W) x 594 (H) mm approx.), completed with recess hinges and flush-key lock.

(c) The graphic shall take the form of a scaled drawing or drawings of the building in which the system is installed, mounted in one framed and glazed enclosure.

(d) The LED display lamp shall be provided on the panel for each fire compartment (zone) as created on the detector loops.

(e) A lamp test push button shall be provided.

(f) The panel shall possess an internal buzzer which shall operate in cases of fire and fault.

(3) *Alarm Report Printer*

(a) The printer shall be a dot-matrix printer type, 80 characters per line and use standard pin-feed paper. The printer shall be enclosed in separate cabinet suitable for placement on a desk top or table. The printer shall communicate with RS-232.

(b) The printer shall provide hard-copy print-out in status of all event changed in status of the system and shall time-stamp such print-outs with the current time of day and date.

(4) *Power Supply*

(a) Source of power supply

(i) The electrical power for fire alarm system shall be supplied through battery charger unit which interconnected with 24 volts dc standby batteries and 220 volt 50 Hz mains supply voltage fed from very essential power source.

(ii) The isolating protective device shall be colored/painted red and labeled "FIRE ALARM : DO NOT SWITCH OFF". Additional warning labels shall be provided where necessary in accordance with the Power Supplies section of NFPA 70 and 72. Fire alarms having more than one source of power supply shall be provided with additional precautionary labels in compliance with the above Codes.

(b) Standby batteries

(i) The standby batteries shall be of the maintenance-free sealed lead-acid type.

(ii) Suitable links shall be provided to facilitate the removal of cells for maintenance or replacement, without interrupting the supply from the charger or to the fire detection/alarm system.

(iii) A separate batteries and charger unit shall be provided in a metal cabinet.

(iv) The batteries capacity shall be adequate for maintaining the system in normal working condition for at least 24 hours during main power supply failure and subsequently to operate in the “alarm” condition for at least 15 minutes.

(v) The batteries shall be brought from fully discharged to fully charged condition within 48 hours.

(c) Battery Charger

(i) The charger shall be trickle type battery charger, suitable for use on a 240 V, 50 Hz single phase supply and is to automatically maintain the 24 V batteries in a state approximate to full charge and at the same time compensate for the standing load.

(ii) The charger shall incorporate the following devices:

1) An indicator lamp to show that the mains supply is healthy

2) A dc voltmeter to show the battery supply is healthy

3) A milli-ammeter to indicate charging current

4) Suitable fuses to protect the equipment

5) Auxiliary contacts for SCADA monitoring

(5) *Initiating Devices*

(a) Heat Detectors

(i) Automatic heat detectors shall be of the analog addressable type using the latest algorithm principles for accurate indication of normal condition, pre-alarm and alarm indications, complete with plug-in base and auxiliary contacts.

(ii) The heat detectors shall be of the combination fixed and rate-of-rise sensors. The fixed temperature setting shall be 57°C (135°F) and rate-of-rise temperature setting shall be 9°C (15°F) per minute.

(iii) The detectors shall comply with the applicable requirements of UL 521.

(b) Smoke Detectors

(i) Automatic smoke detectors shall be of the analog addressable type, using the latest algorithm principles for accurate indication of normal condition, pre-alarm and alarm indications, complete with plug-in base and auxiliary contacts.

(ii) The smoke detectors shall be of the photo-electric type operated on the light scattering principle utilizing a solid-state infrared LED and high speed, light sensing photo diode within its sensing chamber to detect visible products of combustion.

(iii) The detectors shall incorporate a built-in indicating red LED that shall flash in normal state and grow steady in alarm state.

(iv) The detectors shall comply with the applicable requirements of UL 268.

(c) Manually Actuated Alarm-Initiating Devices (Manual Stations)

(i) The manual stations shall be of the pull-down operation (double action), semi-flush mounted type with break-glass and a key for alarm reset.

(ii) The manual stations shall be arranged to operate automatically upon breaking of the glass and pulling down the handle. The glass panel shall be clipped firmly into place. The unit shall be of pleasing appearance and styling, constructed of non-corroding materials and finished in red. The words: "in case of Fire Break Glass and Pull down Handle" shall be displayed upon the front in both Thai and English.

(iii) The units shall be manufactured in bright red compliant material with working on method of operation in white lettering; the cover shall be etched in black lettering in Thai and English "FIRE".

(iv) The glass shall be of the pre-weakened, frangible non-splintering type with a protective plastic coating to prevent operator injury during and after breaking.

(v) The manual stations shall incorporate a test facility for simulating a breakage of the glass for system test purposes. It shall be possible to test without removing the cover or opening the point.

(vi) One spare glass shall be provided for each break-glass unit installed.

(vii) The manual stations will mechanically latch upon operation and remain so until manually reset by authorized personnel opening with a key which is a common key for all the station locks.

(viii) The stations shall comply with the applicable requirements of UL 38.

(6) *Alarm Notification Appliances*

(a) The alarm notification appliances shall be of the combination of audible/visible alarm devices; recess mounted and shall be colored red.

(b) The audible alarm devices shall be of the piezoelectric mini horn producing high sound level (minimum 85 dBA at 10 feet) and in compliance with the applicable requirements of UL 464.

(c) The visible alarm devices shall be xenon strobe light flash with clear lens. The rated strobe output shall be 15/75 candela peak power in compliance with the applicable requirements of UL 1971/UL 1638 consequently. The strobe flash rate shall be 1-2 flash per second.

(7) *Interfacing Relays*

Signals to control other systems by means of dry contacts shall be equipped with a 24V dc relay, with dry contact rating not less than 2 A. Final contact requirement to be agreed in interface coordination.

(8) *Fireman's Telephone Intercommunication*

(a) The act of plugging a handset into an emergency phone jack or removal of any phone from its normal hook position shall cause the appropriate phone location LED to flash and a distinctive audible device to sound at the control panel.

(b) The subsequent picking up of the master phone and acknowledgment of the proper phone circuit shall silence the pulsing tone and cause the phone location LED to stop flashing and remain on. This action shall couple the remote phone to the master phone to provide direct and private communications.

(c) A master telephone control module shall be furnished to provide processing of all two-way communication function. This module shall include an audible alert for call and trouble signaling a trouble silence switch with ring-back, a trouble indication and supervising monitor circuit.

(d) A master telephone control module including with Firemen's telephone handsets in the cabinet shall be installed adjacent to the FCP.

(e) Each emergency phone jack shall be provided and installed adjacent to each manual station. The cover plate of phone jack shall be stainless steel.

(f) One set of portable telephone handset shall be furnished for communication between the FCP in control room and the position of firefighter's telephone outlets in case of fire. The telephone handset shall be completed with 1500 mm coiled cord and single pole phone jack.

(9) *Wiring System*

(a) Recommendation of signal cables:

(i) Twisted-pair with shielded Fire Resistant cable for main control loop and in accordance with manufacturer's recommendation.

(ii) 2.5 mm^2 Fire Resistant cables for power distribute, along with the main control loop, to addressable devices.

(ii) 1.5 mm^2 Fire Resistant cables for manual stations (conventional type) link to addressable modules.

(iii) 2.5 mm^2 Fire Resistant cables for alarm notification appliances (conventional type) link to addressable modules.

(iv) 0.75 mm^2 Fire Resistant cables for Firefighter's telephone jacks link to addressable modules.

(v) 1.0 mm^2 Fire Resistant cables for interfacing relays (or auxiliary contacts) link to other systems as specified.

(b) All signal cables shall be installed in conduits. Supply and return lines must be in separate conduits.

1.16.2.3 Control Logic

(1) Should a fire be detected either by smoke detector; heat detector; firefighting flow switch; gaseous extinguishing system or a break glass unit, the following operation sequence shall be executed.

(2) General alarm; a system general alarm will include the following:

(a) Indicate the general alarm at FCP and annunciator.

(b) Identify the device that is the source of alarm zone at FCP and annunciator.

(c) Initiate all alarm notification appliances.

(d) Alert operation central at OCC via the SCADA system.

(f) Monitor operation of automatic fire suppression systems.

(g) Initiate operation of automatic public address alarm message.

(h) Allow AFC gates to open on transmission of evacuation signal.

(i) Give control signals to lifts control panels.

(j) Give control signals to escalator control panels

(k) Report the event on the system printer.

(3) When a trouble condition is detected by one of the system initiating devices, the following functions shall immediately occur at the control panel and annunciator.

(a) The system trouble LED indicator shall flash.

(b) A local sounding device in the panel shall be activated.

(c) The system CPU & LCD shall indicate all pertinent information associated with the trouble condition and its location. However, unacknowledged alarm message shall have priority over trouble messages.

(d) The appropriate message shall be reported via printer.

(e) The system trouble indicator on remote annunciators shall be illuminated.

(4) Activation of the “Acknowledge Switch” of the control panel shall silence the panel sounding device and change the “System Alarm” or “Trouble LED” from flashing to a steady “ON” condition. In case additional new alarm or trouble conditions exist in the system, activation of this switch shall advance the display to the next alarm or trouble condition that exists, and shall not silence the local audible device or change the flashing LED to steady “ON” until all new conditions have been so acknowledges. New alarm conditions shall always be displayed before new trouble conditions. Activation of the acknowledge switch shall also cause a corresponding (time stamped) message to be print out. Occurrence of a new alarm or trouble condition shall cause the panel to “Resound” and again repeat the sequence.

(5) Activation of the “Signal Silence Switch” shall cause all appropriate indicating appliances and relays to return to the normal condition after and alarm condition. The selection of indicating circuits and relays silenced by this switch shall be fully programmable and changeable in the field.

(6) Activation of the “System Reset Switch” shall cause all electronically-latched initiating devices or zones, as well as all associated output devices and circuits, to return to the normal state. If alarm conditions still exist in the system after the “System reset Switch” activation, the system shall then re-sound the alarm conditions.

(7) Activation of the “Test Switch” of the system shall initiate an automatic test of all intelligent detectors in the system. Such test shall activate the electronics in each intelligent device, simulating an alarm condition. A report summarizing the results of this test shall be displayed automatically on the front panel, as well as on any LCD or printer of the system.

(8) Activation of the “Lamp Test Switch” shall turn “ON” all LED indicators.

(9) Input signals other than from detectors, sprinkler flow switches, and break glass units, and gaseous extinguishing system shall only generate an indication and buzzer alarm but shall not generate a general alarm.

(10) No general alarms to be sounded in passenger areas, to avoid panic. Alarms shall alert staff in control rooms and offices.

(11) From any manual station, authorized personnel with special keys may reset evacuation alarm.

1.16.3 Execution

1.16.3.1 Installation

(1) The Private Party shall install the fire alarm system in accordance with approved Working Drawings and manufacturer's recommendation.

(2) All final connections, tests, adjustments and calibrations shall be made under the direct supervision of a factory-trained technician of the fire alarm system supplier.

1.16.3.2 Testing and Commissioning

(1) These shall prove that:

(a) All equipment cabling and distribution is electrically and mechanically safe.

(b) All exposed metal work is properly bonded and earthed in accordance with the requirements of the appropriate Statutory Requirements and that all connections and points required to be earthed for safe and satisfactory operation are properly earthed in accordance with the manufacturers requirements.

(c) All cables, cores and terminations are properly made off, secure, properly supported and correctly identified and colored.

(d) All phases, polarities, neutral and common connections are correctly switched as required, that power is correctly available at all points and that voltage and frequency at all equipment is correct and in accordance with the requirements for correct working.

(e) All supplies are properly fused, or otherwise protected to give satisfactory discrimination and safe disconnection under fault conditions.

(f) All contacts are properly aligned and not subject to subject to excessive wear or erosion.

(g) All protective covers are properly fitted, all warning and designating labels are correct and in position and the inside of all boxes and cubicles are clean and free of “swarf” and cable striping.

(h) Batteries are properly ventilated, installed, connected and fitted, and that battery chargers are working correctly.

(i) Insulation resistance of all cabling and equipment is not less than that required by the requirements of the appropriate Statutory Authorities.

(j) All instruments and meters are energized with the correct polarity and working properly.

(k) All fault indications and alarms are working correctly.

(l) All essential equipment fed from battery systems continues to function correctly and without disturbance during all supply failures, restoration and standby sequences.

(2) Additional Tests

(a) Additional tests shall be performed to verify that the complete electrical installation shall meet the requirements of this Specification. The list provided below is indicative of the minimum tests required. This also includes the electrical services systems associated with mechanical services, fire protection systems, etc. The Private Party shall develop full test schedules for approval in accordance with the requirements of the Specification.

(b) Cables

(i) Continuity Test.

(ii) Insulation Resistance Test.

(iii) Earth Test.

(iv) Polarity Test.

(c) The Fire Detection & Alarm Systems will be tested in accordance NFPA 70 & 72. Each component and assembly will be type tested and functionally tested before installation, and the entire system functionally tested for correct operation including all interfaces with the other systems.

(d) Minimum required tests are as follows:

(i) Verify that the control unit is in normal condition as detailed in the manufacturers operation and maintenance manual.

(ii) Test initiating and indicating circuits for proper signal transmission under open circuit conditions. One connection each should be opened at not less than 10 percent of the initiating and indicating devices. Observe proper signal transmission according to class of wiring used.

(iii) Test each initiating and indicating device for alarm operation and proper response at the control unit. Test smoke detectors with actual products of combustion.

(iv) Test the system for all specified functions according to the approved operation and maintenance manual. Systematically initiate specified functional performance items at each station, including making all possible alarm and monitoring initiations and using all communications options. For each item, observe related performance at all devices required to be affected by the item under all system sequences. Observe indicating lights, displays, signal tones, and annunciator indications. Observe all voice audio for routing, clarity, quality, freedom from noise and distortion, and proper volume level.

(v) Test both Primary and Secondary Power: Verify by test that the secondary power system is capable of operating the system for the period and in the manner specified.

(e) Complete testing of automatic and manual fire alarm system.

1.17 PUBLIC TELEPHONE SYSTEM

1.17.1 General

1.17.1.1 General Requirement

(1) The Private Party shall furnish and install the public telephone system as specified hereafter and as indicated on the approved drawings at the detailed design stage.

(2) The Private Party shall be responsible in contacting telephone authority for installation of the incoming lines and public telephone subscribers to complete the public telephone works.

1.17.1.2 Standard and Reference

(1) TOT : Telephone Organization of Thailand

(2) CCITT : Consultative Committee on International Telegraphy and Telephony

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

1.17.1.3 Submittals

(1) The details of all material and equipment installations shall be submitted to The Engineer’s Representative for approval before giving the manufacturer a purchase order and installation.

1.17.1.4 Quality Assurance

(1) The equipment manufacturer shall be ISO 9001 certified.

(2) All parts of the system including its performance shall be guaranteed by the manufacturer and/or the Private Party at least two years after handover.

1.17.2 Materials

1.17.2.1 Component

(1) Telephone Terminal Cabinet (TC)

(a) The Telephones Terminal Cabinet shall be fabricated from 1.6 mm (minimum) thick galvanized sheet steel with gray colored epoxy electrostatic powder coated. The protection class shall be IP 31.

(b) Each cabinet shall be provided with full length horizontal and vertical jumper guides.

(c) Each cabinet shall be designed to allow easy door reversal from one side to the other. A rubber sealant strip is fitted to door panels.

(d) A document holder shall be provided inside.

(e) Standard provisions for door lock are flush door lock with key.

(f) The termination block shall support all applications and facilitate cross connection and interconnection using either cross connect wire or patch cords.

(g) The wiring blocks shall be fire retardant, moulded plastic consisting of horizontal index strips for terminating 10 pairs of conductors each. These index strips shall be marked with five colors on the high teeth, separating the tip and ring of each pair, to establish pair location. A series of fanning strips shall be located on each side of the block for dressing the cable pairs terminated on the adjacent index strips. Clear label holders with the appropriate colored inserts shall be provided with the wiring blocks. The insert labels shall contain vertical lines spaced on the basis of circuit size (3-, 4-, or 5-pair) and shall not interfere with running, tracing or removing jumper wire/patch cords.

(h) The terminating block shall be spare capacity of TC at least 25% of the whole lines.

(2) Telephone Cables

4C-0.65mm TIEV cable shall be provided for installation in conduits, between TC and telephone outlets, shall be labeled with sandwich type plastic sheets with letters engraved on the first layer. The plastic sheets shall be tied to the cables nearby the end by releasable cable tie. The works engraved shall indicate the type of the cable and number of pairs, to which terminal boxes it is connected (at both side) and the number of terminations.

(3) Telephone outlets

Telephone outlets shall be modular socket RJ 11 outlets with aluminum cover plate or stainless steel cover plate.

1.17.3 Execution

1.17.3.1 Installation

(1) All equipment and accessories shall be installed in accordance with the manufacturer’s recommendation and as specified on the approved Working Drawings.

1.17.3.2 Testing and Commissioning

(1) The Private Party shall test the system to full function.

1.18 FIRE BARRIER WORK

1.18.1 General

1.18.1.1 General Requirement

(1) After erection of materials and equipment through wall and opening had been completed, it is the responsibility of the Private Party to fill up voids and openings with fire resistant materials which conform to NEC article 300-21 and ASTM to protect fire or smoke from spreading out from one room to another room through these voids and openings.

1.18.1.2 Standard and Reference

The fire barrier shall comply with the following codes and standards.

(1)	NEC article 300.21	:	Spread of Fire or Products of Combustion
(2)	ASTM E814 - 13a	:	Standard Test Method for Fire Tests of Penetration Firestop Systems
(3)	ANSI/UL 1479	:	Fire Tests of Through-Penetration Fire Stops

In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

The standards and codes as mentioned above can be equivalent by another standards and codes, if it equal or better than standards and codes mentioned above when comply between two codes.

1.18.1.3 Submittals

(1) The Private Party shall submit material selector, catalog, material lists, technical data and method of installation for approval prior to proceed purchasing order and installation sequentially.

1.18.1.4 Quality Assurance

(1) The equipment manufacturer shall be latest ISO 9001 certified.

(2) All material and installation of the fire barrier work shall be guaranteed by the Private Party at least two years after handover.

1.18.2 Materials

1.18.2.1 Description

(1) The applied to wall considered to be a fire or acoustical protection wall, unless otherwise specified. Cover or escutcheon plates shall be provided, wherever exposed, and shall be neatly placed to the satisfaction of The Engineer's Representative.

1.18.2.2 Component

(1) The fire barrier materials shall have properties as the following:

(a) The fire barrier materials shall be of a minimum 2-hour fire resistant rating or higher in accordance with type of construction walls or slabs.

(b) The fire barrier materials must not be toxic during installation or in event of fire.

(c) Easy to be dismantled and replaced in case of rearrangement.

(d) Withstand over vibration.

(e) Easy installation.

(f) Before and after fire spreads, the fire barrier materials must be strong enough.

1.18.3 Execution

1.18.3.1 Installation

(1) At every voids and openings, fire barrier materials shall be installed where:

(a) Every voids, sleeves, and openings appear on wall, floor, beam and shaft, provided for raceway installation, must be sealed after the erection work had been completed.

(b) Voids, sleeves, and openings which are provided for future installation.

(c) Voids between electrical conduits and sleeves.

(d) Voids between electrical cabling and raceway on fire wall and floor.

(e) Voids between raceway and sleeves on fire wall and floor.

1.18.3.2 Testing and Commissioning

(1) The testing method shall be provided from the manufacturer.

1.19 STANDARD FIELD TESTS

1.19.1 General

(1) The Private Party is required to submit the Testing and Commissioning Plan which includes a schedule of tests with the identified standards to which the tests are to be carried out. The Private Party shall update the Plan as necessary. The Plan shall include the following:

(a) A detailed description of the test and commissioning philosophy and the testing & commissioning process including the demonstration of a successful Electrical Services.

(b) Details of the testing & commissioning organization set up, including staff responsible for testing & commissioning activities.

(c) Descriptions of methods and procedures for testing & commissioning, the setup of all items of test equipment and all necessary supporting documentation.

(d) Details of the testing & commissioning schedule, management and co-ordination requirements.

(e) Details of how safety shall be addressed for all personnel and equipment during testing and commissioning.

(f) Details of all testing & commissioning standards and guidelines that the Private Party shall follow.

(2) The Private Party shall submit test specifications for all tests including integrated tests to The Engineer’s Representative for acceptance prior to the commencement of the tests and as required by Contract.

(3) The Private Party shall perform testing and commissioning of all equipment supplied and installed under the Contract to verify that the systems and equipment comply with the Authority’s Requirements.

(4) The Private Party shall provide all necessary facilities, labour, equipment, instruments, materials, etc. to carry out testing and commissioning of the system and equipment. All instruments required for testing and commissioning shall be checked and an approved calibration sticker with the calibration validity period indicated prior to use.

(5) The electrical installation shall be functionally tested and checked to ensure that all equipment, devices and wiring have been properly installed and will operate as intended.

(6) The completed equipment and systems shall be tested and balanced by the Private Party.

(7) Field testing shall be required for all cables and electrical equipment furnished, installed or connected by the Private Party to assure proper installation, setting, connection, and functioning in accordance with the plans and specifications and manufacturer's recommendations.

(8) Test all electrical equipment upon completion of installation to ensure that the equipment operates satisfactorily and to conform to Contract Documents.

(9) Testing shall be conducted in the presence of the Engineer’s Representative r and, when necessary, under the supervision of equipment manufacturer's field Engineer’s Representative.

(10) All tests recommended by the equipment manufacturer whether specified in these Specifications or not, shall be included, unless specifically waived by The Engineer's Representative.

(11) Testing shall include any additional tests issued by The Engineer's Representative conditions to determine that equipment, material and system meet requirements of these Specifications.

(12) The Private Party shall maintain in quadruplicate a written record of all tests showing date, personnel making test, equipment or material tested, tests performed and results. Two copies of test records shall be given to The Engineer's Representative.

(13) The Private Party shall notify the Engineer's Representative two weeks prior to commencement of any testing, except for meggerring.

(14) The Private Party shall be responsible for any damage to equipment or material due to improper test procedures or test apparatus handling, and shall replace or restore to original condition any damaged equipment or material.

(15) Safety devices such as rubber gloves and blankets, protective screens and barriers, danger signs, etc. shall be provided by the Private Party and shall be used to adequately protect and warn all personnel in the vicinity of the tests.

(16) The Private Party shall furnish all testing equipment, and furnish temporary power source of proper type for testing purposes when normal supply is not available at the time of testing.

(17) Test all miscellaneous equipment furnished by equipment manufacturer as recommended by the manufacturer i.e., circuit breaker, low voltage switchboard, motor (if any) etc unless specifically waived by The Engineer's Representative.

(18) Include all additional tests issued by Engineer's Representative that he deems necessary because of field conditions, to determine that equipment and material and systems meet requirements of these Specifications.

1.19.2 Testing and Commissioning

1.19.2.1 Site Acceptance Test (SAT)

The list provided below is an indicative minimum of the tests required. The Private Party shall develop full test schedules for clarification to The Engineer's Representative.

(1) General

(a) Check correct CT ratio and polarity and correct operation of all protective gear by primary injection tests and system fault tests to check sensitivity and stability.

(b) Secondary current injection tests for accuracy of relay operations. Protective gear timing tests as may be necessary.

(c) Rotational tests on all motors.

(d) Battery tests on specific gravity, correct output voltage, charging equipment, alarm, etc.

(e) Tests to prove correct operation of all interlocking, tripping and closing circuits, alarm indications, etc. including operation in conjunction with the standby generator for emergency operation of lift, etc.

(f) Phasing test.

(g) The conduit and wiring system shall be checked to ensure that the system has been installed in such a way as to provide a safe and reliable system.

(h) The lighting system shall be checked at night to ensure that illumination levels as specified have been met.

(i) Lighting and control cables shall be meggered phase-to-phase and phase-to-ground.

(j) Power cables, 600 volts rated, shall be meggered phase-to-phase and phase-to-ground before the equipment is connected and phase-to-ground after the equipment is connected and all connection are tapped.

(k) The insulation test of each conductor shall not be lower than the accepted level as required by Authority concerned.

(l) Insulation resistance tests shall be performed by using a 500 V.dc. megger on the 400 volts system. Insulation resistance shall be not less than one mega-ohm per 1000 volts rating.

(m) Grounding resistance shall be checked, using Megger Ground Resistance Test Instrument. The maximum resistance to ground shall not exceed 5 ohms.

(2) Cables

(a) Continuity test;

(b) Insulation resistance test; and

(c) Phasing test.

(3) LV Switchboards

(a) General inspection;

(b) Mechanical tests;

(c) Continuity and Dielectric tests;

(d) Secondary injection test to re-calibrate all measuring, protection and control circuits and associated components;

(e) Phase sequence tests on each outgoing units; and

(f) Functional checks, especially on the controlling devices.

(4) UPS

(a) Full load and half efficiency tests;

(b) Frequency and voltage limits over the whole range of load;

(c) Over voltage and Short circuit protection;

(d) Voltage and frequency regulation during sudden load application;

(e) Overload performance;

(f) Instruments calibration;

(g) Output tests while being supplied from Batteries only;

(h) Battery charging and discharging test;

(i) Simulation tests to simulate all alarms and faults;

(j) System by-pass, mains failure simulation test;

(k) Any other functional tests necessary to demonstrate that the system constructed are fully in compliance with the Specification; and

(l) Measurement of total harmonic distortion (THD) when directed by The Engineer's Representative.

(5) LV System

(a) Continuity of ring final circuit conductors;

(b) Continuity of protective conductors, including main and supplementary equipment bonding;

(c) Earth electrode resistance;

(d) Insulation resistance;

(e) Insulation of site-built assemblies;

(f) Protection by electrical separation;

(g) Polarity;

(h) Earth fault loop impedance; and

(i) Functions of all items of equipment.

(6) Lighting

(a) Illuminance / luminance measurements;

(b) Test to establish correct operation of switching control;

(c) Insulation resistance tests to earth and between conductors before and after fitting of lamps; and

(d) Measurement of leakage current when directed by The Engineer's Representative.

(6) Lightning Protection System

(a) Continuity between air and earth termination; and

(b) Earth electrode resistance.

1.19.2.2 Commissioning

(1) After completion of the field tests, final cleaning of the equipment, removing of all temporary connections or supplies, etc. the commissioning of the plant is to be carried out.

(2) Upon receipt of the Private Party's test records/certificates, The Engineer's Representative shall require to be invited to witness commissioning tests plus the Interface Testing and the Integrated Testing.

(3) After completion of these works the Private Party's Engineer's Representative shall issue a Certificated of Supervision of the Works in a form acceptable to The Engineer's Representative. The Private Party shall submit the final "Operation and Maintenance Manuals" to The Engineer's Representative for his acceptance. The "Operation and Maintenance Manuals" shall include but not limited to the following items:

(a) Maintenance requirements;

(b) Maintenance practices;

(c) Maintenance procedures.

SECTION 2
MECHANICAL VENTILATING AND AIR CONDITIONING SYSTEM

2.0 GENERAL SPECIFICATION

2.0.1 General

2.0.1.1 Introduction

(1) This general specification and requirement describe the materials and installation of the Mechanical Ventilating and Air Conditioning works for building services works and related work for the Project.

(2) The Works shall be executed to completion and in conformity with this specification.

2.0.1.2 Operation

(1) Where the Private Party propose to use material and/or equipment which is not specified or detailed on the drawings, the matter shall be brought immediately to the attention of the Engineer’s Representative who will make a decision.

(2) The locations of air outlets, air duct route and piping route shown on the drawings are diagrammatic, and shall be considered as approximate only. The approved locations may be different from those shown on the drawings, if so directed by the Engineer’s Representative.

2.0.1.3 Environment

(1) The material and equipment shall be installed suitable for tropical climate as mentioned below.

(2) Weather conditions for material and general equipment selection :

(a) Altitude : Approximately mean sea level

(b) Maximum temperature : 40°C (104°F)

(c) Average temperature (all year) : 30°C (86°F)

(d) Maximum relative humidity : 85%

(e) Average relative humidity (all year) : 60%

2.0.1.4 Standards, Codes and Regulations

(1) The entire system and its basic components shall conform in all respects to the standard and regulations of ASHRAE (American Society of Heating, Refrigerating and Air conditioning Engineers). The following standards are mentioned in this specification for systems and/or components and, where described, the systems and/or components shall conform to such standards.

(a) AMCA - Air Moving and Conditioning Association

(b) ANSI - American National Standard Institute

(c) ARI - Air-conditioning and Refrigeration Institute

(d) ASME - American Society of Mechanical Engineers

(e) ASTM - American Society of Testing Materials

(f) BS - British Standard

(g) FM - Factory Mutual

(h) IEC - International Electro-Technical Commission

(i) MEA - Metropolitan Electricity Authority

(j) MWWA - Metropolitan Water Works Authority

(k) NEC - National Electrical Code

(l) NEMA - National Electrical Manufacturers Association

(m) NFPA - National Fire Protection Association

(n) SMACNA - Sheet Metal and Air-conditioning Contractors National Association Inc.

(o) UL - Underwriters' Laboratories, Inc.

(p) Any regulations issued by local authorities.

(2) In the case of conflict or uncertainly in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier one.

2.0.1.5 Scope of Work

(1) The Air Conditioning and Ventilating System work includes the furnishing of materials, labor, equipment, tools, transportation and services required to construct, install and test the complete air conditioning and ventilating system.

(2) It shall be the Private Party's responsibility to provide a completely safe and workable system in accordance with the requirements of this specification, and schedules all to the entire satisfaction of the Engineer's Representative.

(3) The Private Party shall coordinate with other trades to ensure that the system and its components furnished form a complete air conditioning and ventilating system with the established construction schedule.

(4) The entire system and its basic components shall conform to the standards and regulation of ASHRAE. All Standards, codes and regulations shall be the latest issue unless governing authorities require an earlier one.

2.0.1.6 Examination of Drawings and Specifications

(1) The Private Party shall examine all drawings and Specifications to make sure that all requirements are thoroughly understood. In cases where, in his opinion, there are omissions and/or errors in any of these documents, he shall inform the Engineer's Representative immediately.

(2) The Private Party shall examine all relevant architectural and structural drawings, together with all other utilities systems involved in the Project, prior to installation of machines, materials and equipment.

2.0.1.7 Dimensions

(1) Figured dimensions as indicated on the drawings are to be followed and in no case shall dimensions be scaled from the drawings. Wherever possible, dimensions are to be measured from the building.

(2) Before the Private Party commence any works, he shall ensure that dimensions are checked on the site and/or building and agree with those on the drawings.

(3) The Private Party shall be responsible for the accuracy of such dimensions regardless of the comparable dimensions of the drawings.

2.0.2 Material

2.0.2.1 Material and Equipment

(1) All equipment, materials and parts used shall be new and unused, of current manufacture, of the highest quality and free from defects or imperfections affecting the performance or life of the item and approved by the Engineer's Representative.

(2) Unless otherwise specifically indicated on the drawings or in the specification, all materials and equipment shall be installed, with the approval of the Engineer's Representative, in accordance with recommendations of the manufacturer. However, the approval of the Engineer's Representative shall not release the Private Party from his responsibility or his liability regarding the properties and workmanship of installations.

(3) The Private Party shall protect all equipment, material and parts during storage and during construction against the ingress of moisture, contamination or corrosion that might damage the equipment and material.

(4) Certain major equipment defined in the Specifications will be furnished to the Private Party, on site. The Private Party shall assemble, align, level and fix this equipment as instructed by the manufacturer and to the Engineer's Representative satisfaction.

(5) After the materials and equipment have been installed completely in accordance with the instructions, the responsibility for protecting of materials and equipment from damages shall be maintained by the Private Party.

2.0.2.2 Equipment Deviations

(1) Where the Private Party proposes to use an item of equipment other than that specified or detailed on the Drawings, requiring any redesign of the structure, partitions, foundations, piping, wiring or any other part of the mechanical, electrical or architectural layout, all such redesign, including drawings and detailing required shall be prepared by the Private Party at his own risk and then approved by the Engineer's Representative.

(2) Where such approved deviation requires a different quantity and arrangement of cable, conduit, and equipment from the specified or indicated on the Drawings, the Private Party shall furnish and install any such cable, conduit, structural supports, insulation, and any other additional equipment required by the system with the approval by the Engineer's Representative.

(3) In reference to inspection, all works rejected by the Engineer's Representative shall be repaired, corrected or replaced by the Private Party to attain good workmanship, and conform to the consented Working Drawings and approved Specifications. Therefore, ample time shall be provided for inspection and, if there is any defective work re-inspection of the Engineer's Representative shall be performed. In the event that the Private Party should fail to carry out necessary changes, then the Engineer's Representative shall have the right to make its own arrangement Private Party.

2.0.2.3 Tools and Appliances

(1) Unless otherwise stipulated, the Private Party shall provide any pay for all tools and other facilities necessary for the execution and completion of the works.

(2) If at any time prior to commencement or during the progress of works, tools, equipment and materials, in the opinion of the Engineer's Representative, appear to be insufficient, of inappropriate to secure the required quality of works or proper rate of progress, the Engineer's Representative may order the Private Party to increase their efficiency, improve their character, augment their number or replace with new tools, equipment and materials as required.

2.0.2.4 Nameplates and Identifications

(1) All parts of the installation, which are of interest for its operation and maintenance, shall be provided with nameplates, tags or arrows, especially in enclosed areas, such as ceiling, shafts, and other places accessible for maintenance service.

2.0.2.5 Submittal of Data for Approval

(1) The Private Party shall submit to the Engineer's Representative complete information regarding details of materials and equipment involved, prior to any purchase or manufacturing operation. Any purchase or manufacturing operations carried out prior to obtaining such approval shall be at the Private Party's sole responsibility.

(2) The equipment information shall be separately submitted by listing all the details and with attached catalogue indicating at least the model, series, size and performance. Such data shall be sufficient detail to enable the Engineer's Representative to identify that particular product and to form an opinion to its conformity to the Specification.

(3) The Private Party shall stamp the name of his company and sign all documents to be submitted for approval.

2.0.2.6 Approval of Materials

(1) Only new materials and equipment shall be incorporated in the Works. All materials and equipment furnished by the Private Party shall be subject to inspections and approval of the Engineer's Representative. The materials and equipment used for the Works shall correspond to the approved makes or other data. Any materials which, in the opinion of the Engineer's Representative, have lower quality than the approved makes shall promptly be removed from the job site.

(2) Whenever requested by the Engineer's Representative, the Private Party shall send materials to be tested by an independent institute selected by the Engineer's Representative.

(3) If these should be an unavoidable necessity to use materials and equipment that deviate from the specification or from approved samples, then the Private Party shall immediately inform the Engineer's Representative in writing and submit the substitute items of equal quality for approval.

2.0.2.7 Detailed Design Drawings

(1) The Private Party shall prepare detailed design drawings in accordance with the SRT's Requirements – Design, comprising complete details of items to be fabricated and works to be installed. These drawings shall be submitted to the Engineer's Representative for approval before proceeding the preparation of Working Drawing.

(2) Detailed design drawings shall be checked and signed by Registered Engineer of the Private Party. All submitted drawings shall indicate the date of submission and the date(s) of revision(s).

(3) All detailed design drawings shall conform to "Outline Design Specification" and including design criteria and design calculation. The design criteria and design calculation shall be checked and signed by Registered Engineer and submitted to the Engineer's Representative for approval.

(4) Size and scale of the detailed design drawings shall be at least 1:100 scale except for enlarged scale details done for clarity, which shall be in conformity with international standards or as directed by the Engineer's Representative.

(5) Where required by the Engineer's Representative, the Private Party shall prepare additional drawings, diagrams, etc., which in the opinion of the Engineer's Representative are considered necessary for a proper execution of the Works.

(6) The approval of the Engineer's Representative never releases the Private Party from his responsibility or his liability regarding the exact dimensions and any further properties of the installations.

2.0.2.8 Working Drawings

(1) After detailed design drawings have been reviewed and approval by Engineer's Representative, the Private Party shall prepare Working Drawings comprising complete details of items to be fabricated and works to be installed. These Working Drawings shall be submitted to the Engineer's Representative for approval before installation.

(2) The drawings shall be checked by the Private Party for accuracy with regard to dimensions taken in the building(s) and shall closely follow manufacturer's recommendations. All submitted drawings shall be signed by the Private Party, and shall indicate the date of submission and the date(s) of revision(s).

(3) In case Working Drawings require modifications for whichever reason, the Private Party has to clearly identify the portion that was modified, and has to indicate the running number of revision every time that a revision-drawing is submitted.

(4) The installation detailed shall be checked with the building works, the structure and other related trades to prevent conflicts that may cause delay of the project.

(5) Size and scale of the Working Drawings shall be at least 1:100 scale except for enlarged scale details done for clarity, which shall be in conformity with international standards or as directed by the Engineer’s Representative.

(6) Where required by the Engineer’s Representative, the Private Party shall prepare additional drawings, diagrams, etc., which in the opinion of the Engineer’s Representative are considered necessary for a proper execution of the Works.

(7) The Private Party shall not proceed his work for a certain part or section, prior to the approval of the Working Drawings.

(8) Approval of the Working Drawings by the Engineer’s Representative shall not be construed as a complete check but will indicate only the general method of installation and its details are satisfactory.

(9) The approval of the Engineer’s Representative never releases the Private Party from his responsibility or his liability regarding the exact dimensions and any further properties of the installations.

(10) Working Drawings submitted without sufficient detailed shall be rejected and new submission shall be required.

2.0.2.9 As-Built Drawings

(1) The as-built drawings shall record all changes arising during the installation and detail all relevant data concerning makes, types, numbers, capacities, sized and quantities, etc.

(2) The Private Party shall submit to the Engineer’s Representative 3 sets of prints and 1 set of reproducible drawings.

(3) The Private Party shall submit to the Engineer’s Representative 3 sets of DVD or Portable Hard Disk that contained all PDF documents and AUTOCAD file same data as hard copy.

2.0.2.10 Transportation of Materials and Equipment

(1) The Private Party shall submit in advance a transportation schedule of materials to the Engineer’s Representative and coordinate in preparing passage ways and storage facilities.

(2) The Private Party shall be responsible for all expense incurred during shipping and transporting of material and equipment to the job site. The materials and equipment shall be handled in a manner to prevent warping, twisting, bending, breaking, chipping, rusting and any injury, theft of damage or any kind what so ever.

(3) The shipping documents of particular materials and equipment shall be submitted to the Engineer’s Representative as soon as the materials and equipment have arrived at the Site.

2.0.2.11 Materials and Equipment Storage

(1) The Private Party shall prepare storage areas of sufficient size for all necessary materials and equipment brought to the job site. The storage areas shall be provided with access for inspection and removal of the stored materials and equipment.

(2) Materials and equipment delivered to the Site without suitable storage shall not be accepted.

2.0.3 Execution

2.0.3.1 Temporary Power Supply and Others

(1) The Private Party shall connect electrical wires, telephone wires and water pipe for his own use at suitable connection points and shall bear the expense of usage, which shall be removed upon completion of sections of the Works.

2.0.3.2 Responsibility

(1) The Private Party shall establish, maintain, and supervise all precautions and programs for safety and provide protection to prevent damage, injury or loss to :

(a) All workmen on the worksite and other persons who may be affected thereby.

(b) All works and all materials or equipment to be incorporated herein, whether in storage on or off the site.

(2) As the work proceeds, the Private Party shall progressively remove rubbish and surplus materials away from the construction site and shall maintain his working area in a clean and tidy condition as far as is practicable.

(3) Upon completion of the Works he shall, without delay, remove all his temporary works and buildings, all tools, equipment and surplus materials, and shall clean the whole area affected by his work and leave it ready for immediately occupation.

(4) All materials, equipment and finished works shall be kept in good condition. The completed work shall be the Private Party's property until handed over to the Engineer’s Representative.

2.0.3.3 Field Testing

(1) Test all equipment upon completion of installation to ensure that the equipment operates satisfactorily and to conform to the PPP Contract Documents.

(2) Field testing shall be required for all Air conditioning and Ventilating System equipment furnished, installed or connected by the Private Party to assure proper installation, setting, connection, and functioning in accordance with the plans, specifications and manufacturer's recommendations.

(3) Testing shall be conducted in the presence of the Engineer’s Representative and, when necessary, under the supervision of equipment manufacturer's field engineer.

(4) All tests recommended by the equipment manufacturer whether specified in this specification or not, shall be included, unless specifically waived by the Engineer’s Representative.

(5) Testing shall include any additional tests issued by the Engineer’s Representative conditions to determine that equipment, material and system meet requirements of the specifications.

(6) The Private Party shall maintain in triplicate, a written record of all tests showing date, personnel making test, equipment or material tested, tests performed and results. Three copies of test records shall be given to the Engineer’s Representative within the following day.

(7) The Private Party shall notify the Engineer’s Representative two weeks prior to commencement of any testing, except for metering.

(8) Private Party shall be responsible for any damage to equipment or material due to improper test procedures or test apparatus handling, and shall replace or restore to original condition any damaged equipment or material.

(9) Safety devices such as rubber gloves and blankets, protective screens and barriers, danger signs, etc. shall be provided by the Private Party and shall be used to adequately protect and warn all personnel in the vicinity of the tests.

(10) The Private Party shall furnish all testing equipment and furnish temporary power source of proper type for testing purposes when normal supply is not available at the time of testing.

2.0.3.4 Operation and Maintenance Instructions Manual

(1) The manual shall be prepared in hard cover building in sets to be submitted to the Engineer's Representative on acceptance of the completed work.

(a) Section 1 Comprises submittal data of all equipment and materials that have been approved.

(b) Section 2 Comprises catalogues, categorized in groups, complete with installation operations and the maintenance manuals from the manufacturers.

(c) Section 3 Comprises filled out test reports in the field.

(d) Section 4 Comprises spare parts list and recommended spare parts.

(e) Section 5 Comprises maintenance and services schedule, and service and maintenance procedures for individual equipment listed daily, weekly, monthly, quarterly and yearly.

(f) Section 6 Comprises system operation manual

(2) A draft copy of the manual shall be submitted to the Engineer's Representative for approval first.

2.0.3.5 Asset List

(1) General

(a) The Private Party shall produce an asset list of all main equipment. The SRT or Engineer's Representative have an option to include other accessories with consideration of availability on local market, high value and importance to operation.

(b) The Private Party is responsible for developing a data based information of the asset list or use of commercial software for asset management. Software operating system shall be Windows based (Windows 8) or as agreed with the SRT and the Engineer's Representative.

(c) The list data based shall be capable exported to Asset Management Software of the SRT.

(d) The list shall be submitted in conjunction to the Operation and Maintenance Instruction Manual to the SRT or Engineer's Representative for approval.

(2) Asset Data Based Requirement

The Private Party shall develop an asset list form and issued to the SRT and the Engineer's Representative for approval but shall contain information not limited to the following items:

(a) Asset number : Referring to tags installed in each equipment

(b) Equipment unit number

(c) Equipment description : Type and Capacity

(d) Manufacturer, Model number, Serial number, Date manufactured

(e) Expected service life

(f) Service warrantee Information : Start and expire date

(g) Manufacturer contact information

(h) Number of units

(i) Initial value of equipment

(j) Location : Name of building, room and area serve

(3) Asset Number

The Private Party shall install asset numbering labels on all equipment included in the list and shall be in accordance to the Specification stipulated in Equipment Identification and Labeling Section.

2.0.3.6 Works to Completion

(1) The Private Party shall commission, clean down, and leave in full working order the works as specified.

(2) As the installation proceeds the Private Party shall prepare record drawings of the HVAC installation, as built drawing. It will be sufficient to modify these contract drawings showing any amendments to the service which have taken place and submit the marked-up prints to the Engineer's Representative for approval.

(3) The Private Party shall deliver to the Engineer’s Representative on completion of the works, manufacturer's literature, specifications, technical information and record drawings for all equipment installed.

2.1 PACKAGED WATER COOLED CHILLER

2.1.1 General

2.1.1.1 General Requirement

(1) The Private Party shall furnish and install the completely package water cooled centrifugal or screw chillers as shown on specified herein.

(2) The chillers shall be specially designed for 50 Hz. electrical systems.

(3) The Private Party shall provide the standard hand tools specified in the standard catalog from the manufacturer including brushing for inner tube cleaning.

2.1.1.2 Standards and References

(1) The units shall comply with the following codes and standards

(a)	ARI 550/590	:	Standard for Water Chilling Packages Using the Vapor Compressions Cycle
(b)	ANSI/ASHRAE 15	:	Safety Code for Mechanical Refrigeration
(c)	ANSI/ASME Section VIII	:	Boiler and Pressure Vessel Code
(d)	ARI 575-87	:	Method of Measuring Sound within Machinery Room

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

2.1.1.3 Submittals

(1) The Private Party shall submit Chiller’s performance selection, material lists and technical data for approval before purchasing.

(2) Chiller units shall undergo performance testing by the manufacturer in full compliance to the ARI standard 550/590, the performance test points shall be taken in 5 minutes interval at each load conditions set at 100%, 75%, 50% and 25%. Test points data collection on each load conditions shall be done and recorded at least 3 times.

The performance data sheet with the affixed signature of the lab personnel shall be submitted to the client and project manager for review before shipment.

(3) The Private Party shall submit the following technical data for approval before installation:

(a) Dimension plan and elevation view drawing of the chiller, required clearances, and location of all field piping and electrical connections.

(b) Diagram of control system indicating points for field interface and field connection.

(c) Installation and operation manuals

2.1.1.4 Quality Assurance

(1) Equipment manufacturer must be specializing in the manufacturing of the products specified and shall have ten (10) years experience with the equipment and refrigerant offered.

(2) The equipment must comply with the codes and standards in specified in Item 2.1.1.2

(3) The equipment manufacturer plant shall be ISO 9000 certified

2.1.1.5 Delivery and Handling

(1) Chiller unit shall be stored and handled in accordance with manufacturer instruction.

(2) Chiller unit shall be shipped with all refrigerant piping and factory installed control wiring.

(3) Chiller unit shall be shipped with oil and refrigerant charge from factory.

(4) Chiller unit shall be shipped firmly with attached labels indicating name or manufacturer, model number, serial number, and refrigerant used.

2.1.1.6 Warranty

(1) The chiller's manufacturer warranty shall include parts and labor cost for two (2) years after handover.

2.1.2 Material

2.1.2.1 Description

(1) The chillers shall be package type, each consisting of a compressor, motor, water cooler, condenser, economizer, lubricating system, electrical and control wiring, unit control panel, etc. The equipment shall specifically be designed for the refrigerant HFC-134a, HFC-407c, HFC-410a or other refrigerant which have zero ODP and GWP.

(2) Compressor shall be centrifugal, screw or scroll hermetic type, single stage or multi-stage, direct drive or gear drive.

(3) The chiller shall be operated at partial load between 25% - 100% at the entering condenser water temperature 32.2 OC (90 OF) without any failure or surging.

2.1.2.2 Components

(1) Compressor

(a) Centrifugal compressor shall be of single stage or multi-stage, hermetic type. The impeller shall be statically and dynamically balance. Compressor shall be fully field serviceability.

(b) Screw compressor shall be single or multiple compressors, hermetic or semi-hermetic type direct driven compressor.

(c) Scroll compressor shall be single or multiple compressors, hermetic type with refrigerant cooled, direct driven compressor.

(2) Motor

(a) Centrifugal compressor motor

(i) Motor shall be of the hermetic, liquid refrigerant cooled or Suction Gas Cooled Refrigerant, single speed, non-reversible, squirrel cage, induction type.

(ii) Motor shall have a minimum of 95% efficiency and 85% power factor. Full load operation of the motor shall not exceed nameplate rating.

(iii) Motor design speed shall be 2950 RPM and suitable for 380 Volt/3 Phase/ 50 Hertz power supply.

(b) Screw compressor motor

(i) Motor shall be of the hermetic or semi-hermetic type, single speed, non-reversible, squirrel case, induction type.

(ii) Full load operation of the motor shall not exceed nameplate rating.

(iii) Motor design speed shall be 2950 RPM. And suitable for 380 Volt/ 3 Phase/ 50 Hertz power supply.

(c) Scroll compressor motor

(i) Motor shall be of the hermetic, suction gas cooled, single speed, squirrel cage, induction type.

(ii) Full load operation of the motor shall not exceed nameplate rating.

(iii) Motor design speed shall be 2950 RPM and suitable for 380 Volt/ 3 Phase/ 50 Hertz power supply.

(3) Lubrication system

(a) Centrifugal compressor

(i) Lubrication system shall have a complete force feed lubricating system with pump, cooler, crankcase heater, reservoir, filter, etc. to provide and adequate supply or oil to transmission and bearing during startup and shut down, as well as during normal operating conditions.

(ii) All safety and control devices shall be suitable for operation on single phase alternating current of 50 hertz frequency and voltage not exceeding 250 volt.

(iii) Power supply for oil pump and oil heater shall be feed from essential power supply.

(iv) System in which lubricating oil comes in contact with the refrigerant shall be provided with thermostatically controlled electric oil heaters of adequate capacity in order to prevent foaming of the oil due to change in pressure and absorption of refrigerant into the oil during compressor shut down.

(v) Oil cooler shall be refrigerant cooled or water cooled type.

(vi) Oil filler with isolation valves to allow filler change without removal of refrigerant charge.

(b) Screw compressor

Screw compressor using oil injection for motor sealing shall incorporate arrangements to prevent excessive oil carry over with refrigerant from the compressor and ensure adequate oil return to the compressor over the full operating range.

(c) Scroll Compressor

(4) Evaporator and Condenser

(a) The evaporator and condenser shall be designed, constructed and tested in accordance with ASME and ANSI-B 9.1 Code requirements and recommendations of ARI standard 550. Working pressure of the water side vessel shall not be less than 10 bar or the figure shown in the equipment schedule. The fouling factor for both evaporator and condenser shall not be more than 0.000044m2 $^{\circ}$k/w.

(b) The evaporator and condenser shall be of the shell and tube type operating with refrigerant in the shell and water in the tubes. The tubes shall be of copper or 8% red brass construction and shall be individually replaceable. The shell shall be of steel construction. Each evaporator and condenser shall be of minimum 2 pass construction.

(c) Water boxes shall be made of cast-iron or welded steel or Carbon Steel. They shall be arranged so as to permit inspection of tubes from either end without disturbing the refrigerant chamber or the chilled water/condenser water piping connections. Water boxes shall be provided with hinged covers to facilitate tube cleaning.

(d) The evaporator shell shall be insulated with at least 25mm thick closed cell insulation. The insulation shall have thermal conductivity of less than 0.038W/m^{o}k. Three layers of emulsion acrylic paint shall be applied over the insulation after the insulation has been installed.

(e) Evaporator and condenser shall be provided of water differential pressure switch. (The water flow switch paddle type is not acceptable).

(5) Control devices

(a) The controller of the chiller shall be of a microprocessor type complete with all hardware and software necessary to enable to interface with all other generic building automation system. The controller shall at least have the following main function:

(i) Chilled water temperature control

(ii) Condenser water temperature control

(iii) Motor current limiting controls

(iv) System cycling controls

(v) System shutdown controls

(vi) Operating sequence control of condenser pumps, cooling tower, chilled water pump and chiller.

(vii) Other necessary safety controls e.g. low evaporator pressure cutout, high condenser pressure cutout, low oil pressure cutout etc.

(b) The microprocessor based control center shall be factory mounted. The chiller operating parameters shall be sensed and displayed on the keypad which shall at least have the following function:

(i) Return and leaving chilled water temperatures.

(ii) Return and leaving condenser water temperatures.

(iii) Evaporator and condenser refrigerant pressures.

(iv) Differential oil pressure.

(v) Motor current in % full load amps.

(vi) Compressor discharge temperature.

(vii) Purge pressure. (if applicable)

(viii) Other temperature as recommended by the manufacturer.

2.1.3 Execution

2.1.3.1 Installation

(1) Each chiller shall be mounted on steel spring isolators which are, in turn, placed on a concrete base. The isolators shall be selected and installed in accordance with the manufacturer's recommendation such that no disturbing vibration or noise is being transmitted to the nearby structure.

(2) The Private Party shall provide and installed Refrigerant Sensor in chiller plant room for detected refrigerant leakage. The Installation shall be compliance to the ARI standard 15 latest version.

(3) The Private Party shall provide and installed refrigerant pipe from Refrigerant Pressure Relief Valve to outside air and as recommended by Chiller's manufacturer.

2.1.3.2 Testing and Commissioning

(1) Chiller units shall undergo performance testing by the manufacturer in full compliance to the ARI standard 550-92. The performance test points shall be taken in 5 minutes interval at each load conditions set at 100%, 75%, 50% and 25%. Test points data collection on each load conditions shall be done and recorded at least 3 times.

(2) After installations are completed, all equipment shall undergo test run. Any adjustments that are needed shall be made to assure that all equipment will operate either the required performance. Report forms to contain following minimum data listings shall include design and actual conditions for each Item mentioned below:

(a) Date and time of test.

(b) Chiller make, type, name and serial number.

(c) Number of pumps running.

(d) Flow rates for chilled water.

(e) Temperatures of chilled water at inlet and exit of pumps, chillers, etc.

(f) Pressures of chilled water at inlet and exit of pumps, chillers, etc.

(g) Flow rates for condenser water.

(h) Temperatures, as above.

(i) Pressures, as above.

(j) Compressor motor data.

(k) Compressor rpm.

(l) Suction and hot gas temperatures.

(m) Suction and hot gas pressure.

(n) High pressure cutout.

(o) Condensing temperature.

(p) Evaporator temperature, pressure drop.

(q) Differential Pressure Switch Function

(r) Chiller automatic control sequencing, including the interlocking of all the chillers.

2.2 COOLING TOWER

2.2.1 General

2.2.1.1 General Requirement

(1) The Private Party shall furnish and install cooling towers including all necessary equipment as specified herein.

(2) The cooling tower shall have a heat rejection capacity of not less than the specified in the performance schedule.

2.2.1.2 Standards and References

(1) The cooling tower shall comply with the following codes and standards:

(a) CTI STD-201 (02), Standard for Certification of Water-Cooling Tower Thermal Performance

(b) CTI Code ATC-105 (00), Acceptance Test Code for Water-Cooling Towers

(c) JCT : Japan Cooling Tower Institute

2.2.1.3 Submittal

(1) The Private Party shall submit technical information, calculation sheet, cooling tower performance selection and all necessary information for approval before purchasing.

(2) The Private Party shall note the dimensions of the cooling towers and space for installation before final selection.

2.2.1.4 Warranty

(1) All parts of the cooling tower shall be guaranteed by the manufacturer and/or by the Private Party for at least two (2) year.

2.2.2 Material

2.2.2.1 Description

(1) The cooling tower shall be designed for outdoor installation and shall be assembled at the site.

(2) The cooling Towers shall be constructed with casing, fan, motor, filling, drift eliminator, water distribution system, collection water basin and accessories.

(3) Unless otherwise indicated, each cooling tower shall be selected to achieve a noise level not more than ASHRAE standard or CTI standard.

(4) The cooling tower's performance shall be certified by CTI or JCI.

(5) The cooling tower shall be classified into three (3) types as the followings:

(a) Induced draft counter flow type, this type of cooling tower shall have water flow and air flow in the counter flow direction, and the air shall be induced by propeller or axial fan. The cooling tower shall be round or square shape, single-cell or multiple-cell type.

(b) Induced draft cross flow type, this type or cooling tower shall have water flow and air flow in the cross flow direction, and the air shall be induced by propeller or axial fan. The cooling tower shall be rectangular type, single-cell or multiple-cell, and of low noise type construction.

(c) Force draft counter flow type, this type of cooling towers shall have water flow and air flow in the counter flow direction, and the air shall be force to the water by the centrifugal fan. The cooling tower shall be rectangular shape, single-cell or multiple-cell, and of low noise type construction.

2.2.2.2 Component

(1) Casing and Frame Work

(a) Induced draft counted flow and cross flow type

(i) Casing shall be constructed of fiberglass reinforced polyester (FRP) casing. It shall be designed to resist corrosion and withstand severed vibration and heavy win forces.

(ii) The basic framework shall be constructed of hot-dip galvanized steel coated with zinc.

(iii) Air inlets shall be designed so as to prevent back splash at any rate of water flow up to 140 percent or rated capacity with or without air flow.

(iv) Louver shall be of polyvinyl chloride (PVC) or fiberglass reinforced polyester (FRP).

(b) Forced draft counted flow type

(i) Casing shall be constructed of hot-dip galvanized steel.

(ii) The structure framework shall be designed to resist corrosion and withstand severed vibration and heavy wind forces.

(2) Filling and Filling support

(a) Filing shall be constructed of polyvinyl chloride (PVC) of corrugated and embossed to provide maximum air to water contact for optimum heat transfer efficiency and low air side pressure drop. The PVC filling shall be self-extinguishing. The filling shall be made accessible for cleaning.

(b) The filling must withstand a maximum water temperature of 55 deg.C (131 deg.F) and be resistant to rot, decay or biological attack.

(c) The filling shall be supported by hot-dip galvanized steel support in order to achieve the uniform water distribution.

(3) Drift Eliminator

(a) Cooling Tower shall be provided with drift eliminators or other means of limiting drift loss. Drift eliminators shall be constructed or polyvinyl chloride (PVC).

(b) Drift loss shall not exceed 0.02 percent of rated water flow.

(4) Water Distribution System

(a) Water distribution system shall be designed that a water flow of 140 percent of rated water flow will not cause overflowing or an armful splashing.

(b) For the Cooling Tower will used hot water basin, the hot water distribution basin shall be open gravity type made of FRP or galvanized steel sheet. The hot water basin shall distribute water uniformly over the entire fill area. Cast Iron/Bronzed body flow control valve with locking bar shall be installed to balance the flow of water to each cell and each side of cell.

(c) For the Cooling Tower are used water spray nozzle or sprinkler, the spray header and branches shall distribute water uniformly over the entire fill area. The spray headers shall be constructed of aluminium alloy, PVC or HDPE and shall be automatically operated when the water flow through them. Spray nozzles shall be large orifice and non-clogging design.

(d) Cold water basin shall be constructed of fiberglass reinforced polyester (FRP) or hot-dip galvanized steel with a smooth internal surface. Cold watch basins for each cooling tower shall be design for separation to facilitated cleaning. The capacity of each basin shall be of sufficient volume in order to prevent air being sucked into the suction line of pump during operation.

(e) Basin shall be provided with an inlet, outlet, equalizer, overflow, drain, float controlled make-up and quick filed connection.

(5) Fan

(a) For induced draft cooling tower, fan shall be of the axial flow type with airfoil section blades and made of aluminium alloy. It shall be of ample capacity to overcome the resistance of the tower and shall be quiet in operation. A heavy wire mesh guard shall be provided on the air outlet of the fan. Fan speed reducer shall be gear driven or belt driven.

(b) For force draft cooling tower, fan shall be of centrifugal forward curve, double width double inlet (DWDI) designed and shall be statically and dynamically balanced. Fan housing shall be designed to minimize static pressure loss and increase fan efficiency. Fan shall be mounted on a steel shaft supported at each end with self aligning, self lubricating ball bearings with cast iron housings.

(6) Motor

(a) Fan motor shall be located out of the hot air stream.

(b) Fan shall be driven by a 1450 RPM, 380 V/ 3Ph/50Hz totally enclosed fan cooled (TEFC) motor. Each motor shall be insulation class F and protection class IP55 and shall be based on a service factor of 1.15. The motor shall be of ample size to enable the fan to operate under all operating conditions. The motor shall be of a high efficiency type.

(7) Bolts and Nuts

All bolts, nut, and washers used for outdoor installation should be of stainless steel type.

2.2.3 Execution

2.2.3.1 Installation

(1) The cooling tower shall be supported by steel spring isolators, which have static deflection of not less than 25 mm. (1 inch.) or as specified on the drawing. The isolators shall be selected and installed in accordance with the manufacturer's recommendations.

(2) All piping which connects to the cooling tower shall be provided with flexible pipe connections.

(3) Where the electrical panel board is not local to the Cooling Tower there shall provide a weather proof disconnection switch adjacent to the Cooling Tower.

2.2.3.2 Testing and Commissioning

(1) The Private Party shall be adjusted water flow on the hot water basin to be balanced on both sides.

(2) For multiple-cell cooling tower operation, the Private Party shall provide balancing valve of each cooling tower to balanced water flow rate of each cooling tower.

(3) After installations are completed, all cooling towers shall be test run. Any adjustments that are needed shall be made to assure that all cooling towers will operate either the required performance. Report forms to contain following minimum data listings shall include design and actual conditions for each Item mentioned below:

  (1) Date and time of test.

  (2) Ambient conditions at time of test.

  (3) Cooling tower make, type, name and serial number.

  (4) Number of pumps running.

  (5) Flow rates for condenser cooling water.

(6) Temperatures of condenser water at inlet and exit of pumps, cooling towers, etc.

(7) Pressures of condenser water at inlet and exit of pumps, cooling towers etc.

(8) Number of fans working in cooling towers.

(9) Amount of bleed water added during the test period.

(10) Automatic bleed-off control sequencing.

(11) Make-up water control sequencing.

2.3 WATER PUMP

2.3.1 General

2.3.1.1 General Requirement

(1) Water pumps shall be selected based on the information detailed in the equipment schedules and installed in accordance with the standard detail.

(2) The water pumps used for the same function shall be of the same manufacturer. Unless otherwise specified, the pump shall be selected for a best total efficiency and selected at non-overloading performance curve.

(3) The water pumps shall be supplied by famous representative in Thailand with available spare parts.

2.3.1.2 Standards and References

(1) The water pump shall comply with the following codes and standards.

(a) ASTM A159-83(1993) - Standard Specification for Automotive Gray Iron Castings

(b) ASTM B584-00 - Standard Specification for Copper Alloy Sand Castings for General Applications

(c) ASTM B36/B36M-95 - Standard Specification for Brass Plate, Sheet, Strip, and Rolled Bar

(d) ASTM A48/A48M-00 - Standard Specification for Gray Iron Castings

2.3.1.3 Submittals

(1) The Private Party shall submit pump performance curves, material lists and technical data for approval.

(2) The pump supplier shall submit certificate test of origin from manufacturer before the pump on site.

2.3.1.4 Warranty

(1) All part of the water pump shall be guaranteed by the manufacturer and/or by the Private Party for at least two (2) year.

2.3.2 Material

2.3.2.1 Description

(1) Water pumps shall be centrifugal, single stage or multi-stage volute type. They shall be horizontal split case or end suction or vertical inline. They shall be driven by electric motors with flexible couplings. The pumps and motors shall be mounted on steel base plate.

(2) The pump type shall be as follows:

(a) Horizontal Split Case Centrifugal Type

(a) Pumps shall be of the non-overloading, centrifugal, volute type. They shall be of the horizontal split case, double suction type with suction and discharge connections in the lower half of the casing.

(ii) The pump shall allowing removal of the rotating element without disturbing pipe connections and operating at a speed of not over 1500 rpm.

(b) End Suction Centrifugal Type

(i) Pumps shall be of the single-stage horizontal end suction centrifugal type, operating at a speed of not over 1500 rpm.

(b) The pumps shall be designed so that removal of the pump impeller will not interfere with the piping system (back pull-out pump).

(c) In-line Centrifugal Type

(a) Pumps shall be of the single-stage vertical mounted. Split coupled (for all capacity) or close coupled (capacity not more than 500gpm) design, in-line centrifugal type, single suction with volute type casing operating at a speed of not over 1500 rpm.

(ii) The pumps shall be designed so that removal of the pump impeller will not interfere with the piping system (back pull-out pump).

2.3.2.2 Component

(1) Casings

(a) Casings of all pumps shall be designed for a working pressure not less than 1.5 times of the actual discharge pressure, whichever is greater.

(b) Pressure classification of flange connections shall correspond to casing working pressures.

(c) Casing material shall be cast-iron, precision-manufactured for best performance and long-term duty.

(d) Water discharge diffusers shall be included to reduce radial torque to the impeller.

(2) Wearing Rings

(a) All pumps having discharge connections larger than 50 mm. and operating at more than 207 kPa. (30 psi.) the total dynamic head shall be provided with casing wearing rings. These rings shall be suitable for an individual application.

(b) Rings shall be replaceable, and positively keyed to prevent rotation.

(3) Impellers

(a) Impellers shall be one-piece, cast-bronze and dynamically balanced. Impellers of pumps having 40 mm. and larger discharge connection shall be fully enclosed and hydraulically balanced.

(b) Impellers shall be accurately keyed to the shaft and fixed in an axial position by shaft sleeves and separate snap rings.

(c) Impellers shall be fully protected against damage due to reverse rotation.

(4) Shafts

(a) Shafts for pump with stuffing boxes shall be of stainless steel, (chrome-iron or nickel-iron) extending through the stuffing boxes. Where stuffing boxes are used, shafts shall be provided with water slingers. Shafts shall be designed with high safety precautions to withstand easily the torsional loads with other stresses to which they may be subjected. They shall be so designed that there will be no detrimental vibrational stresses. All shaft threading shall be external to the water passage and stuffing boxes.

(b) Shaft sleeves shall be keyed to the shaft and extended through the stuffing box.”O” rings or gaskets shall be provided at sleeve ends to protect the shaft from water corrosion. They are so designed that no dismantling of the pump casing is required to replace the sleeves.

(5) Bearings

(a) Bearings shall be heavy-duty ball bearings with a minimum average life of 100000 hours.

(b) The bearings shall be self-sealed, and house in malleable-iron housing aligned to a bearing bracket by means of large precision registers.

(c) Bearings shall be removable without dismantling any rotating element inside the pump.

(6) Stuffing Boxes

(a) Stuffing boxes shall be deep enough for no less than 4 rings of packing and shall have bronze glands.

(b) Packing shall be suitable in all cases for the service required with proper consideration of water pressure, temperature, temperature changes and sediment carried in the water.

(c) Mechanical seals shall be provided in lieu of stuffing boxes as specified in pump schedules.

(7) Couplings

(a) All pumps, other than close-coupled pumps shall be provided with urethane flexible couplings or steel pins and bushing with service factor of at least 1.5 for an individual application.

(b) The flexible couplings shall be with space sleeves to allow dismantling of the entire bearing bracket of the pump including shaft seal and impeller without detaching the motor from the base plate.

(c) Couplings shall impose no restriction normal end play or expansion. Suitable coupling guards shall also be provided.

(8) Base Plate

Each flexible coupled pump shall be provided with a cast-iron or fabricated steel base plate to hold both the pump and the motor in correct alignment pumps and motors shall be accurately aligned. (9) Miscellaneous Fittings

(a) High points of pump casings shall be provided with air vent cocks. These cocks shall be extended outside of any insulation. Low points of casings shall be provided with drain valves and both inlet and outlet connections with properly located gauge tapping.

(b) Casing brackets of pumps equipped with stuffing boxes shall be arranged to from drip pockets. A drip pipe shall be run from each drip pocket to the nearest drip funnel or floor drain.

(10) Motors

(a) The pump shall be driven by a 1450 rpm, 380V/3 / 50 Hz. Totally enclosed fan-cooled, insulation class F and protection class IP54 electric motor and IP 55 for outdoor motor. The rated kW shall be at least 1.15 times of the maximum power required.

(b) The motors shall be of a high efficiency design and should be supplied as an integral part of the pump. The Private Party shall submit technical data for approval.

(c) Bearing of each motor shall be of anti-friction type ball bearing or roller bearings.

(d) Motor terminal box shall be waterproof.

2.3.3 Execution

2.3.3.1 Installation

(1) Anti-vibration

Each pump shall be mounted on inertia base and spring isolators which are placed on a concrete foundation. The minimum static deflection of spring isolators shall be 25 mm. (1 inch). They shall be selected and installed in accordance with the manufacturer's recommendations such that no disturbing vibration and noise is being transmitted to the nearby structure.

(2) Insulation

Chilled water pumps shall be insulated with at least 25 mm. thick closed cell foam plastic insulation. (See pipe insulation)

(3) Pumps shall be installed by following the manufacturer recommendations.

(4) Ensure that no cavitation occurs at the eye of the impeller

(5) Any suction and discharge pipes, which are bigger than the pump connections shall be equipped with eccentric reducers.

(6) Flexible connections shall be installed on both the suction and on the discharge pipe.

(7) Shut-off valve and strainers shall have the same size as the suction pipe. Check valve and shut-off valve shall have the same size as the discharge pipe.

(8) Drainage from each pump shall be discharged to the nearest drain. Each drain pipe shall be of galvanized steel pipe as detailed within this specification.

2.3.3.2 Testing and commissioning

(1) Before start-up, grease or lubricating oil shall be applied to the pump and motor.

(2) After installations are completed, all pumps shall undergo test run. Any adjustments that are needed shall be made to assure that all pumps will operate either the required performance. Report forms to contain following minimum data listings shall include design and actual conditions for each Item mentioned below:

(a) Date and time of test.

(b) Ambient conditions at time of test.

(c) Pump make, type, name and serial number.

(d) Pump rpm.

(e) Pump amperage (Individual Operation).

(f) Pump amperage (Multiple Operation).

(g) Rated motor amperage, starter relay number and amperage rating.

(h) Pump inlet pressure (Individual Operation).

(i) Pump inlet pressure (Multiple Operation).

(j) Pump outlet pressure (Individual Operation).

(k) Pump outlet pressure (Multiple Operation).

(l) Chilled water flow rate GPM (Multiple Operation).

(m) Condenser cooling water flow rate GPM (Multiple Operation).

(n) Water temperatures.

(o) Water flow rate GPM.

2.4 CHILLED WATER AIR HANDLER

2.4.1 General

2.4.1.1 General Requirement

(1) The Private Party shall furnish and install the air handler as shown on specified herein.

(2) Air handler shall be the same manufacturer as chiller’s manufacturer.

2.4.1.2 Standards and References

(1) The air handler shall comply with the following codes and standards.

(a)	ARI 260	:	Standard for Sound Rating of Ducted Air Moving and Conditioning Equipment
(b)	ARI 410	:	Standard for Forced Circulation Air-Cooling and Air-Heating Coils.
(c)	ARI 430	:	Standard for Central Station Air Handling Units.
(d)	NFPA 90A	:	Installation of Air Conditioning and Ventilation Systems.
(e)	ASHRAE 68	:	Laboratory Method of Testing In-Duct Sound Power Measurement Procedure for Fans.
(f)	ANSI/AFBMA 9	:	Load Ratings and Fatigue Life for Ball Bearings.
(g)	ANSI/UL 900	:	Test Performance of Air Filter Units.
(h)	AMCA 300	:	Reverberant Method for Sound Testing of Fans.
(i)	AMCA 301	:	Method for Publishing Sound Ratings for Air Moving Devices.
(j)	SMACNA	:	HVAC Duct Construction Standards.
(k)	NFPA 90A	:	Standard for the Installation of Air-Conditioning and Ventilating Systems

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

2.4.1.3 Submittal

(1) The Private Party shall summit air handler's performance selection, material lists and technical data for approval.

(2) The Private Party shall note the dimensions of the air handlers and space for installation before final selection.

2.4.1.4 Warranty

(1) All part of the air handler shall be guaranteed by the manufacturer and/or by the Private Party for at least two years after handover.

2.4.2 Material

2.4.2.1 Description

(1) Each air handler shall consist of an air filter, cooling coil, fan, drip pan, and casing. The unit mounting arrangement and air discharge direction shall be selected to proper space for installation and shall be with proper clearances for maintenance and replacement of parts.

(2) All air handlers shall be factory made by one manufacturer. If necessary they may be ordered in semi-knock-down condition and the assembly may be done on site.

(3) All insulation and adhesive used in the unit shall comply with NFPA 90A requirements for flame spread and smoke index.

(4) Type of air handler shall be specified as shown on specified herein. General classification type shall be as the following

(a) Double skin air handling unit

(b) Single skin air handling unit

(c) Fan coil unit

2.4.2.2 Component

(1) Double Skin Air Handling Unit

(a) Double skin air handling unit will be modular system and have double wall panels and injected insulation with polyurethane foam between the two panels.

(b) Casing

(i) Casing shall be constructed of heavy gauge galvanized steel sheets not less than 1.3 mm. thickness. These sheets shall be heavily braced and stiffened to prevent vibration and hold all working parts rigidly in line and shall be reinforced with angles or channels as required. In lieu of galvanizing, approved baked enamel will be acceptable. The casing panels shall be removable for easy access to the interior.

(ii) The coil section shall be securely mounted in zinc-coated sheet steel casing arranged for bolting to other sections.

(iii) Duct work and casings, etc. shall be supported on angle frames or other strong and rigid construction. Insulation for the cooling coil section and fan section shall be coated with 25 mm. fire-resistance glass wool blanket with a density of not less than 48 kg /m^3, with either vinyl, asphaltic, plastic or neoprene coating on the side expose to air or closed cell elastomeric foam. Insulation shall be secured to the casing with an adhesive applied over the entire back. All seams and joints in insulation shall be completely sealed.

(iv) The condensate drain pan shall be made of steel not less than 1.3 mm. thickness and shall be insulated with 25 mm. sheet of waterproof rigid fiberglass fastened to the pan. Drain pans shall have at least two drain connections at a low point of the pan.

(c) Fan

(i) Fan shall be of the centrifugal type, forward curved or backward curved or airfoil blade type mounted on a single shaft. It shall be of the double width, double inlet type.

(ii) Fan housing shall be of heavy gauge galvanized steel, die-formed with stream-lined inlets designed to eliminate eddy and shock.

(iii) The fan wheel or impeller shall be of mild steel, fabricated construction and well formed shroud and shall be both statically and dynamically balanced. Shafts shall be steel, either solid or hollow, and ground to close tolerances on all working surfaces. Shafts shall operated well within their critical speeds.

(iv) Bearing shall be of the self-aligning, pre-lubricated, sealed type, mounted in cast-iron housing, and shall have balls and races specially lapped and individually tested and selected for quiet operation. Bearings shall be equipped with externally accessible grease fittings and shall be of a size designed to assure an average operating life in excess of 100,000 hours.

(v) The fan shall be statically and dynamically balanced.

(d) Motor and Drive

(i) Both fan and motor shafts shall be provided with proper size grooved pulleys for belt drive with belt guard. Belts shall be of the oil-resistant type and sized for 115 per cent of the rated kW.

(ii) Each motor for a V-belt drive shall be fitted with variable pitch pulleys. The pulleys shall be key-slotted and set-screwed to the shafts. All combined parts shall be statically and dynamically balanced. Motor shall be of the totally enclosed fan-cooled type, 1450 rpm, 380V/ 3 / 50 Hz. Insulation class B and protection class IP 54.

(e) Cooling Coil

(i) Cooling coils shall be of the extended surface type, constructed of copper or brass tubing with helical or plate fins of copper or aluminum extending at right angles to the tubes. They shall be of the serpentine type and have inlet, outlet, vent and drain connections for each section. Serpentine coils shall be accurately leveled.

(ii) Cooling coils shall have a sufficient area to prevent suspended moisture from being carried into the air-stream. Coils shall be selected for a maximum coil face velocity of 2.54 m /s (500 fpm.)

(iii) Water pressure drop across the coil shall not exceed 6.5 m. (15 ft.) of water. Tube thickness shall be not less than 0.04 times the outside diameter. Tubes shall be soldered or brazed to headers unless the headers are thick enough or provided with bosses heavy enough to withstand, without undue distortion, the stresses due to rolling or expanding the tubes. Pressure parts of coils shall be constructed and tested under water for a pressure of not less than 1,034 kPa. (150 PSIG.)

(iv) Fins shall be spaced not closer than 2.1 mm. (maximum 12 FPI). Cooling coils shall be suitably protected during shipment and installation so that fins and casing flanges will not be damaged. Coils having loose or damaged fins at the time of final inspection shall be rejected and must be replaced with new coils.

(v) Cooling coil shall be 3-6 rows. It the air handler required more than 6 rows coil, coil shall be split to 2 coils which have spacing not less than 500 mm. (20”).

(f) Anti-Vibration

(i) Double skin air handling units shall be built-in the internal spying isolator place inside the fan section.

(ii) All vibration isolators shall be selected and installed in accordance with the unit manufacturer’s recommendations so that no disturbance is caused in the surroundings.

(2) Single Skin Air Handling Unit

(a) Single skin air handling unit will have single wall panels with internal insulation using either fiberglass with aluminium foil or closed cell elastomeric foam.

(b) Casing: Casing shall be same as 2.4.2.2(1) Clause (b).

(c) Fan: Fan shall be same as 2.4.2.2(1) Clause (c).

(d) Motor and drive: Motor and drive shall be same as 2.4.2.2(1) (Clause (d).

(e) Cooling coil: Cooling coil shall be same as 2.4.2.2(1) Clause (e).

(3) Fan coil unit

(a) Interior Chassis

Interior chassis shall be constructed of not less than 16 AWG galvanized steel. All cold panel surfaces shall be covered with 25 mm. fire-resistant glass wool blanket with a density of not less than 48 kg /m3(3lb /ft3), with either vinyl asphaltic plastic or neoprene coating on the side expose to cold air. The insulation shall be securely attached and of sufficient thickness and density-to prevent condensation on the unit casing and to protect against deterioration caused by air currents. The insulation shall be fire-retardant material.

(b) Casing

The units shall be manufactured of cold-rolled steel bond and coated with baked-on enamel finish. The casing shall be of a sufficient size to enclose all piping and shall have access doors to piping and controls. The thickness of all panels shall not be less than 18 AWG. All panel and/ or access doors shall be easily and quickly removable for inspection and access to all internal parts.

Casings shall be provided with properly reinforced points of support for either the setting or handling of the unit.

(c) Cooling Coil

Cooling coils shall have sufficient capacity for the load indicated. They shall be copper tubing with aluminum fins mechanically bonded to the coils. Fins spacing shall allow full coil cooling under wet conditions. Coil bends shall be enclosed within the insulated end sections of the basic unit for protection against moisture. Maximum air velocity across the coils shall be 2.3 m/s (450 fpm.). Coils shall be suitable for working pressure not less than 1,034 kPa (150 PSIG) with air vents.

The internal structure of the coil section shall allow coils to be removable and have suitable baffles to assure no air bypass around the coil.

(d) Fan and drive

Fans shall be double-width, double-inlet forward curve centrifugal and so designed for quiet operation. They shall be mounted on a rigid shaft in self-aligning bearing and accessible for service. The unit shall be complete with fan speed control switches of high, medium, low, and off control.

(e) Drain Pan

The drain pan shall be coated with anti rust material. It shall be provide at a low part in the drain pan. The connection shall be made possible on either side of the unit the drain pan shall be fabricated of not less than 1.3 mm. galvanized steel with all corners welded. The condensate drain pan shall be insulated with 25 mm. insulation to prevent condensation.

(f) Motor

Motor shall be of the permanent split capacitor type and shall have sufficient torque to start on low speed. It shall have three-speed winding and shall be factory-wired to a junction box. The motor shall be suitable for 220V /1 /50 Hz. Electrical characteristic with integral overload protection.

2.4.3 Execution

2.4.3.1 Installation

(1) Air handling unit shall be mounted on spring isolators placed on a concrete base. Unless other wised the air handling unit have built-in internal spring isolators, the unit shall be maligned on rubber pad placed on a concrete base.

(2) Fan coil units shall be mounted on rubber-in-shear vibration isolators or spring isolators hanger.

2.4.3.2 Testing and commissioning

(1) After installations are completed, all air handlers shall be test run. Any adjustments that are needed shall be made to assure that all air handlers will operate either the required performance. Report forms to contain following minimum data listings shall include design and actual conditions for each Item mentioned below:

(a) Date and time of test.

(b) Air handling unit and fan coil unit make, type, name and serial number.

(c) Fan rpm.

(d) Pressure drop across filter

(e) Fan discharge static pressure

(f) Fan motor amperage

(g) Rated motor amperage, starter number and ampere rating.

(h) Re-circulated air CFM

(i) Outside air CFM

(j) Outside condition (DB and WB)

(k) Return air condition (DB and WB)

(l) Entering coil condition (mixing) (DB and WB)

(m) Leaving coil conditions (DB and WB)

(2) During test run, the air filters of testing sets shall be used.

2.5 SPLIT TYPE AIR CONDITIONER

2.5.1 General

2.5.1.1 General Requirement

(1) The Private Party shall furnish and install split type air conditioner as shown on specified herein.

(2) The split type air conditioner shall be specially designed for 50 Hz. electrical systems.

2.5.1.2 Standards and References

(1) The split type air conditioner shall comply with the following codes and standards.

(a)	ANSI/ASHRAE 128-2001	:	Method of Rating Unitary Spot Air Conditioners (ANSI Approved)
(b)	AMCA 301	:	Method for Publishing Sound Ratings for Air Moving Devices
(c)	TIS 1155-2536	:	Split Air Conditioner (Small Unit)
(d)	TIS 2134-2553	:	Room Air Conditioners : Energy Efficiency

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

2.5.1.3 Submittal

(1) The Private Party shall submit split type air conditioner's performance selection, matching curve, material lists and technical data and all necessary information for approval before purchasing.

2.5.1.4 Warranty

(1) All part of the split type air conditioner shall be guaranteed by the manufacturer and/or by the Private Party for at least two year after handover.

(2) All compressors shall be guaranteed by the manufacturer for at least 5 year.

2.5.2 Material

2.5.2.1 Description

(1) The unit shall be assembled and matching parts from factory as standard model. The unit consisting of outdoor Condensing Unit and indoor Air handler are connected with refrigerant pipe and electrical wires, part of each section will be described below:

(2) Evaporator unit, condensing unit, refrigerant pipe, filter drier, sight glass, shall be installed in properly location or advised by the manufacturer.

(3) The air conditioning equipment shall be air cooled, spit system suitable for HFC-407c or HFC-410a or any zero ODP refrigerant, factory tested, evacuated dehydrated and pressurized with refrigerant holding charge for field installation. The unit shall be in accordance with the following Specifications as stated below.

2.5.2.2 Component

(1) Condensing Unit

(a) The condensing unit shall be air cooled, weatherproof type for outdoor installation. The unit shall consist of the following:

(b) Casing shall be made of 18-gauge (1.3 mm.) steel sheet, bonded and finished with baked enamel. The casing may be made of aluminum or fiberglass with equivalent strength.

(c) Compressor shall be hermetic type. All compressors shall be mounted on vibration isolators. They shall be equipped with internal overload (overheated) protectors,

(d) Electricity characteristic shall be 220/1/50 or 380/3/50.

(e) Condenser coil shall be seamless copper tubes with mechanically expanded into aluminum fins, leak tested and pressure tested at 3,100 kPa (450 psig).

(f) Condenser fan shall be direct drive protected by heavy gauge rust resisting wire guard.

(g) Fan motor shall be permanent-split-capacitor, inherently protected and permanently lubricated bearings.

(h) There shall be low and high sides access valves for pressure measuring.

(i) Control shall be factory wired and located in a separate enclosure. They shall consist of the following safety devices.

(i) Control and fan motor fuses size not be over 6 amperes.

(ii) High-low pressure switch, except compressor with a capacity less than 12 kW. (42,000 BTUH)

(iii) Magnetic starter.

(iv) Timer or time delay (3-6 minutes delay time) especially designed for air conditioner except compressor with a capacity less than 12 kW. (42,000 BTUH)

(j) Standard accessories for condensing unit shall include the following:

(i) Thermal overload

(ii) Compressor contact relay

(iii) High and low pressure switch

(iv) Refrigerant dryer

(v) Liquid indicator

(vi) Suction and liquid lines shut-off valves

(vii) Refrigerant charging port

(viii) Safety switch

(2) Evaporator Unit (Air Handling Unit / Fan Coil Unit)

(a) Casing shall be made of steel sheet, bonded and finished with baked enamel insulated with 12 mm (1/2") thick, 40 kg/cu.m. (2.5 lb/cu.ft.) density mat-faced fiber glass or steel. The casing may be made of aluminum or fiberglass with equivalent strength.

(b) Evaporator coil shall be seamless copper tube with mechanically expanded into aluminum fins. Coils shall be leak tested and pressure tested at 2,069 kPa. (300 psig.)

(c) Blower or fan shall be centrifugal type.

(d) Motor shall be permanently lubricated bearings mounted on vibration isolators.

(e) Electricity characteristic shall be 220/1/50 or 380/3/50 as indicated on the Drawings.

(f) Air filter shall be washable type.

(3) Cooling Capacity

(a) The cooling capacity and system design condition shall be indicated on design calculation sheets.

(b) If the system design condition not shown, the cooling capacity shall be matching capacity of condensing unit and air handling unit, based on the following conditions :

(i) Air on condenser - dry bulb temperature 35° C (95° F)

(ii) Air on evaporator - dry bulb temperature 26.7° C (80° F)

- wet bulb temperature 19.4° C (67° F)

(iii) Maximum face velocity of air through evaporator 2.54 m/s (500 ft/min)

(iv) Maximum compressor discharge pressure corresponding to 51.7° C (125° F) condensing temperature.

(v) Saturated suction temperature 3° C - 9° C (38° F - 47° F)

(4) Refrigerant Pipe

(a) Refrigerant pipes shall be copper tube hard drawn type L, suction lines shall be insulated with closed cell foamed plastic of not less than 20 mm (3/4 inch) thick, and wrapped with PVC tape for exposed pipe only.

(b) Suction and liquid lines shall be separated and fixed with clamps at every 2.5 m. (8 ft.) interval.

(c) Pipe insulation at the fixed points shall be covered with galvanized steel of not less than 100 mm. (4 inches) long.

2.5.3 Execution

2.5.3.1 Installation

(1) The split type air conditioner shall be mounted on vibration isolators and installed in accordance with the manufacturer's recommendation such that no disturbing vibration or noise is being transmitted to the nearby structure.

(2) Refrigerant pipes that exposed to outdoor shall be cover with aluminium pipe jacket for protected insulation from direct UV exposure.

2.5.3.2 Testing and Commissioning

(1) After installations are completed, all air handlers shall undergo test run. Any adjustments that are needed shall be made to assure that all air handlers will operate either the required performance. Report forms to contain following minimum data listings shall include design and actual conditions for each Item mentioned below:

(a) Date and time of test.

(b) Air handling unit and fan coil unit make, type, name and serial number.

(c) Fan rpm.

(d) Pressure drop across filter

(e) Fan discharge static pressure

(f) Fan motor amperage

(g) Rated motor amperage, starter number and ampere rating.

(h) Re-circulated air CFM

(i) Outside air CFM

(j) Outside conditions (DB and WB)

(k) Return air conditions (DB and WB)

(l) Entering coil conditions (mixing) (DB and WB)

(m) Leaving coil conditions (DB and WB)

(2) During test run, the air filters of testing sets shall be used.

2.6 PRECISION AIR CONDITIONER

2.6.1 General

2.6.1.1 General Requirement

(1) The Private Party shall furnish and install the precision air conditioner as shown on specified herein.

(2) The precision air conditioner shall be specially designed for 50 Hz. electrical systems.

(3) Evaporator unit, condensing unit, refrigerant pipe, filter drier, sight glass, shall be installed in advised by the manufacturer.

2.6.1.2 Standards and References

(1) The precision air conditioner shall comply with the following codes and standards.

(a) ANSI/ASHRAE 128-2001 : Method of Rating Unitary Spot Air Conditioners (ANSI Approved)

(b) AMCA 301 : Method for Publishing Sound Ratings for Air Moving Devices

(c) TIS 3008-44 : Standard for the Installation of Split Air Conditioning (Small Unit)

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

2.6.1.3 Submittal

(1) The Private Party shall submit precision air conditioner performance sedation, matching convey, material lists and technical data for approval.

2.6.1.4 Warranty

(1) All unit components shall be guaranteed by the manufacturer or by the contraction for at least two years after handover.

(2) All compressors shall be guaranteed by the manufacturer at least 3 years.

2.6.2 Material

2.6.2.1 Description

(1) The air conditioning equipment shall be air cooled, remote condenser system suitable for HFC-134a, HFC-407c, HFC-410a or any zero ODP refrigerant, factory tested, evacuated dehydrated and pressurized with refrigerant holding charge for field installation. The unit shall be in accordance with the following Specifications as stated below.

(2) Precision air conditioner shall be extendable modular type. Each module is provided with its own air section, electrical section and cooling section. They shall be design for maintenance access from the front.

(3) Type of precision air conditioner shall be classification type of the units shall be as follows:

(a) Classify by air flow direction

(i) Down flow : The units will be discharge cold air on the bottom and intake air (return air) on the top.

(ii) Up flow : The units will be discharge cold air on the top and intake air (return air) on the front.

(b) Classify by cooling system

(i) Air cooled direct expansion (DX) refrigerant cooling system with remote air cooled condenser.

(ii) Chilled water cooling system.

(iii) Water cooled direct expansion (DX) cooling system with water cooled condenser.

(iv) Dual circuit cooling system, this type is consist of two system are describe above.

2.6.2.2 Component

(1) Indoor air unit

The indoor air unit shall consist of the following:

(a) Frame and Housing

(i) The unit consists of a frame made of natural color aluminum extruded profile and inner steel walls serving for air direction of highest stability.

(ii) The unit is closed on all sides with removable doors. All parts of housing which are in direct contact with water are made of aluminum and lifetime protect against corrosion.

(b) Exterior Panel Work

(i) The panel work is lined out with a noise absorbing insulation, which is thermally treated. The thickness of insulation is minimum 32 mm.

(ii) Panels are designed to a total air pressure difference of minimum 1000 Pa.

(c) Evaporator

(i) The evaporator shall be seamless copper tube with mechanically expanded into aluminum fins. Coils shall be leak tested and pressure tested at 2,069 kPa. (300 psig.)

(ii) The evaporator coil shall be inclined position and aluminum condensate drain pan.

(d) Fan and Blowers

(i) Fan shall be of the centrifugal type, forward curved blade type mounted on a single shaft. It shall be of the double width, double inlet type low revolutions and low noise emission.

(ii) Fan housing shall be of heavy gauge galvanized steel, die-formed with stream-lined inlets designed to eliminate eddy and shock.

(iii) The fan wheel or impeller shall be of mild steel, fabricated construction and well formed shroud and shall be both statically and dynamically balanced. Shafts shall be steel, either solid or hollow, and ground to close tolerances on all working surfaces. Shafts shall operate well within their critical speeds.

(iv) Bearing shall be of the self-aligning, maintenance free pre-lubricated, sealed type, mounted in cast-iron housing, and shall have balls and races specially lapped and individually tested and selected for quiet operation.

(v) Bearings shall be equipped with externally accessible grease fittings and shall be of a size designed to assure an average operating life in excess of 100,000 hours.

(e) Motor and Drive

(i) Both fan and motor shafts shall be provided with proper size grooved pulleys for belt drive with belt guard. Belts shall be of the oil-resistant type and sized for 115 per cent of the rated kW.

(ii) Each motor for a V-belt drive shall be fitted with variable pitch pulleys. The pulleys shall be key-slotted and set-screwed to the shafts. All combined parts shall be statically and dynamically balanced. Motor shall be of the totally enclosed fan-cooled type, 1,450 rpm, 380V/3 ϕ / 50 Hz. insulation class B and protection class IP54.

(f) Compressor

(i) Compressor shall be hermetic type. All compressors shall be mounted on vibration isolators on the unit housing. They shall be equipped with internal overload (overheated) protectors.

(ii) Compressor and other heat emitting components shall be located separately from the air stream

(iii) The accessories for refrigerant circuit shall be provided and installed completely from factory i.e. filter dryer, sight glass with moisture indicator, thermostatic expansion valve, high and low pressure switch.

(iv) Electricity characteristic shall be 220/1/50 or 380/3/50.

(g) Heater

(i) Electrical reheat shall installed per module, made of chrome-nickel steel finned rods, fins made of chrome-nickel steel to reduce surface temperature and frame made of galvanized steel.

(ii) Each stage is protected by an overheat thermostat and an addition circuit breaker in electrical box in the module.

(h) Humidifier

(i) Steam humidifier shall be installed per module with a nominal pressure is 1-6 bars. Stream capacity shall be in the range of 25-100% of the nominal capacity adjustable on the unit. Completely steam cylinder with the boiling electrodes.

(ii) The humidifier is separated from the airflow stream and can be service without interrupting the operation of the unit.

(i) Water Leak Detector

(i) The water leak detector sensing cable provided completed with the unit module. The sensing cable are installed under raised floor and detect water leakage under the unit. The cable detects the presence of water at any point along their length.

(ii) The sensing cable constructed of 2 sensor wires and continuity wire embedded in a Fluoropolymer carrier rod. The cable structure has no alarm error when touching any steel

(2) Air Cooled Condenser Unit

(a) The air-cooled condenser shall be one condenser per refrigerant circuit.

(b) The condenser made of corrosion resistant aluminum casing, suitable for horizontal or vertical installation.

(c) Condenser coil shall be seamless copper tubes with mechanically expanded into aluminum fins, leak tested and pressure tested at 3,100 kPa. (450 psig.).

(d) Condenser fan shall be direct drive protected by heavy gauge rust resisting wire guard.

(e) Fan motor shall be permanent-split-capacitor, inherently protected, permanently lubricated bearings.

(f) There shall be low and high sides access valves for pressure measuring.

(g) Terminal box for power input shall be water protected IP54.

(3) Master Controller

(a) The controller produces by the same manufacturer as precision air conditioner. The controller is provided for controlling of and a precision air conditioner unit and supervising of room temperature and humidity limits.

(b) The controller can control the operation of stand-by module and duty module by the configuration at least:

(i) Fault Start : The stand-by module will automatic changeover in the unlikely even of failure of duty mode.

(ii) Alarm Start : The stand-by module will be start automatically to maintain the room condition in the case of temperature or relative humidity out of limited value.

(iii) Sequencing : The automatic duty sharing between stand-by module and duty module ensures all module have the same operating time. Thus each module takes over the stand-by function for a defined time.

(4) Front Panel / Display Face

(a) Front panel equipped with user friendly large surface LCD display. The software is structured in three different levels: Information, Operation and Service, which can be operated by a user friendly windows base via the display and the keys consists of;

(i) Selector Button : Select manus and change parameter

(ii) Confirmation : Acknowledge function and parameter

(iii) On/Off Switch : On/Off

(iv) LED Alarm : LED lights up in the event of alarm

(v) Audible Indicator : The audible indicator issues and alarm tone when the alarm signals in the display.

(b) The controllers have to display at least:

(i) Actual values of temperature and relative humidity and display of the temperature and humidity curve over at last 24 hours.

(ii) Symbols for operation modes cooling, reheat, dehumidification and humidification of every modules.

(iii) The RS232 provide for printer interface or for interface with building management system (BMS).

(iv) The graphic display can be switch to various languages and different character including both English and Thai.

(v) Module and component running time.

(vi) The previous 60 alarms with date and time, alarm delays adjustable, priorities of the alarm.

(vii) Maintenance request symbol appear when the service required.

(viii) The alarm signals have to transmit via the controller (front panel), paper, mobile phone and fixed line. The front panel alarm with LED indicator and audible alarm with the following display at least:

(ix) Temperature too high / too low

(x) Humidity too high / too low

(xi) Clogged filter

(xii) Compressor high / low pressure

(xiii) Water leak alarm

(5) Supervisor Controller

(a) The Supervisor controller produces by the same manufacturer as precision air conditioner unit. Each controller has to provide complete with own supervisor controller.

(b) The supervisor controller acts as a supervisor to the controller and takeover the controller in the event of failure by keeping the same parameter and all features as master controller and front panel and every module still operation with current status.

2.6.3 Execution

2.6.3.1 Installation

(1) The precision air conditioner shall be mounted on vibration isolators and installed in accordance with the manufacturer's recommendation such that no disturbing vibration or noise is being transmitted to the nearby structure.

(2) Refrigerant pipes that installed outdoor shall be cover with aluminium pipe jacket for protected insulation from direct UV.

(3) Condensing unit shall be supported with steel and rubber to the frame and covered with rustproof and external paint.

(4) Location of on/off switch and thermistor or temperature controller shall be installed on manufacturer standard, In case of installation problems that cannot be mounted as indicated, supervisor shall indicated the proper location for installation.

(5) Vibration isolator shall be provided and noise control shall be concerned for installing each air-conditioning unit.

(6) Conduit of Electric wiring shall be metal tube. EMT-type shall be installed within indoor area. And IMC Type shall be installed outdoor area.

(7) Conduit of transmission wiring shall be the type of conduit of Electric wiring tube.

(8) Connection of conduit shall be waterproofed flexible for outdoor area and normally flexible for indoor area.

(9) The fuse or non-fuse safety switch for each system shall be installed as near as possible to the condensing unit and be of a suitable capacity as recommended by the a/c equipment manufacturer.

(10) Power cables (including power supply to air conditioner) and signal cables must not be laid inside the same conduit (Power cables and signal cables must each have their own individual conduits).

(11) Interlocking system shall be provided for condensing unit and fan coil unit in operation, while fan coil unit is off or condensing unit in operation before fan coil Fuses shall be provided in control system.

2.6.3.2 Testing and Commissioning

(1) Operating test run shall be provided from manufacturer.

(2) After installations are completed, precision air conditioner shall undergo test run. Any adjustments that are needed shall be made to assure that all precision air conditioner will operate either the required performance. Report forms to contain following minimum data listings shall include design and actual conditions for each Item mentioned below:

(a) Date and time of test.

(b) Air handling unit and fan coil unit make, type, name and serial number.

(c) Fan rpm.

(d) Pressure drop across filter

(e) Fan discharge static pressure

(f) Fan motor amperage

(g) Rated motor amperage, starter number and ampere rating.

(h) Re-circulated air CFM

(i) Outside air CFM

(j) Outside condition (DB and WB)

(k) Return air condition (DB and WB)

(l) Entering coil conditions (mixing) (DB and WB)

(m) Leaving coil conditions (DB and WB)

(3) During test run, the air filters of testing sets shall be used.

2.7 AUTOMATIC CONDENSER TUBE CLEANING

2.7.1 General

2.7.1.1 General Requirement

(1) The Private Party shall furnish and install the completely automatic condenser tube cleaner as shown on specified herein.

(2) The automatic condenser tube cleaning shall be supplied by the famous representative in Thailand with available spare parts.

2.7.1.2 Standards and References

(1) The automatic condenser tube cleaning shall comply with the following codes and standards.

(a)	ASTM A53/A53M-04a	:	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
(b)	ASTM B75-02	:	Standard Specification for Seamless Copper Tube.
(c)	TIS 277-1989	:	Galvanized steel pipes
(d)	BS 1387 (1985)	:	Medium Black & Galvanized Steel Pipe
(e)	BS 143 & 1256 (1986)	:	Malleable cast iron and cast copper alloy threaded pipe fittings

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

2.7.1.3 Submittals

(1) The Private Party shall submit the automatic condenser tube cleaning's performance selection, material list, technical data and all necessary information requested for approval.

(2) The Private Party shall note the dimensions of the unit and space for installation before final selection.

2.7.1.4 Warranty

(1) All part of the unit shall be guaranteed by the manufacturer and/or by the Private Party for at least two years after handover.

(2) The Private Party shall investigate every 2-3 months and supplied cleaning bail for at least 2 years.

2.7.2 Material

2.7.2.1 Description

(1) The automatic condenser tube cleaning is a device for cleaned the condenser tube of the Chiller automatically and interlocking with the Chiller.

(2) The unit shall be low maintenance and low energy consumption, except only changed the cleaning balls.

(3) The automatic condenser tube cleaning shall consist of cleaning ball, ball injector, ball collector or ball trap, valve and automatic control panel. Parts of the unit are described as the following:

2.7.2.2 Component

(1) Cleaning ball shall be made of sponge ball or electrometric rubber ball. The cleaning ball shall be soft enough for condenser tube and shall not made damage to the tubes.

(2) Ball injector shall be made of mild steel and furnished with baked on enamel. The ball injector is used for collected the ball, cleaned the ball and injected the ball to the system.

(3) Ball collector or ball trap shall be made of mild steel and furnished with baked on enamel. The ball collector constructed of stainless steel ball strainer or other material that can be used for high temperature and high corrosion. The ball collector shall not disturb condenser water flow for a minimum pressure drop.

(4) Valve and accessories shall be standard valves, which are used in the Air Conditioning system. The valves and accessories can be seen in Section 2.12.

(5) Control panel shall be microprocessor control or programmable logic control (PLC). The control can be controlling of start/stop the unit by interlocking with chiller and injected ball to the system automatically.

2.7.3 Execution

2.7.3.1 Installation

(1) Ball injector shall be mounted on concrete foundation with neoprene acoustic pad on spring isolator such that no disturbing vibration and noise being transmitted to the nearby structure.

(2) Ball collector pipe and ball injector pipe to the condenser water piping system shall be installed shut-off valve for service the automatic condenser rube cleaning.

(3) Drainage from each unit shall be discharged to the nearest drain. Each drain pipe shall be of galvanized steel pipe as detailed within this specification.

2.7.3.2 Testing and Commissioning

(1) Operating test run shall be provided by the Private Party.

2.8 WATER CONDITIONING SYSTEM

2.8.1 General

2.8.1.1 General Requirement

(1) The Private Party shall fully furnish and install the water conditioning system including all necessary accessories as show on the Drawings and/or specified herein.

(2) The water conditioning system shall be supplies by the famous representative in Thailand with available spare parts and chemical supply.

2.8.1.2 Standards and References

(1) The water conditioning system shall comply with the following codes and standard.

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

2.8.1.3 Submittals

(1) The Private Party shall submit chemical calculation, equipment selection, material lists and technical data for approval before purchasing.

(2) The Private Party shall submit installation drawing.

2.8.1.4 Warranty

(1) All parts of the system shall be guaranteed by the Private Party and/or by the manufacturer for at least 2 years.

(2) The Private Party shall provide chemicals for the system at least 2 years consumption.

2.8.2 Material

2.8.2.1 Description

(1) The water conditioning system shall consist of corrosion and scale protection, automatic bleed-of control, and sort water for make-up water to cooling towers.

(2) The Private Party shall provide all the parts and components to complete the system operation.

2.8.2.2 Component

(1) Chemical treatment

(a) The Private Party shall provide complete corrosion and scale protection and algae growth protection by a chemical method for both chilled water and condenser water. The calculation of chemical consumption, installation drawings, technical bulletins, and dosing program shall be submitted for approval.

(b) The Private Party shall provide chromate corrosion inhibitors and chemicals for biocide algae growth protection for 12 months consumption.

(c) A complete set of pH, chromate, chloride and hardness test kit, shall also be provided by the Private Party. During guarantee period, the Private Party shall be responsible for taking water supply periodically analyze and check the quality of water. The Private Party shall train MRTA to use water quality test kit.

(d) The Private Party shall provide a competent representative to assemble, install and interconnect equipment for chemical treatment. The representative shall be from or recommended by the manufacturer of equipment. The representative shall also perform the running and testing of the plant, to place it in operation. The Private Party shall provide operation and maintenance manuals to MRTA.

(e) Methods of chemical feeding system shall be as follows :-

(i) Corrosion and Scale Protection

- For Condenser Water

  The chemical feeding system shall include chemical tank for 15-day operation, mixer and metering pump. The metering pump shall be adjustable flow and controlled by timer.

- For chilled water

  The chemical feeding system shall be of the bypass diffusion type.

(ii) Biocide Protection

The chemical feeding system for condenser water shall be of the bypass diffusion type or metering pump. Shock feeding shall be applied occasionally during guarantee period according to the water expert's recommendation.

(2) Automatic Bleed-Off Control

(a) The bleed-off system shall operate automatically by weatherproof control valve, which is commanded by temperature-compensated conductivity cell. The indicator controller shall be of the industrial type suitable for the required function. The control voltage shall be of low voltage.

(b) Accumulative type water meter shall also be provided.

(3) Cooling Tower Make-up Control

(a) Softeners

(i) The softener shall treat raw water with a total hardness of about 200 PPM and reducing to 10 PPM or less with a pressure drop of not over 70 kPa. (10 PSI.) The continuous treating rate capacity of the softener shall be at least as indicated on the Drawings.

(ii) The softener shall consist of cylindrical mild steel tank with inside and outside epoxy coated with a design pressure not less than 700 kPa. (100 PSI.). The tank shall contain strong action exchange resin for catching calcium and magnesium. When a certain volume of raw water has been treated the softener shall be automatically regenerated by brine solution (sodium chloride). There shall be one standby unit and shall be automatically interchanged with the duty unit in every regeneration cycle without any interruption of soft water supply to the cooling towers.

(iii) The automatic regeneration control shall be with either adjustable timer or adjustable aqua-sensor control. The unit shall be fully automatic with necessary accessories motorized/solenoid valves, sight glass, pressure gauges etc.

(b) Brine Tank

The brine tank shall be matched with the softener. It shall be made of fiberglass-reinforced polyester or polyethylene. The valves, mixer and other necessary accessories shall be made of stainless steel if applicable in order to withstand brine solution.

(c) The make-up water control for cooling tower shall operate automatically by mechanical float valve. The valve shall be rugged and heavy duty. The floating ball shall be made of bronze.

(d) All necessary valves and accessories shall be provided as recommended by cooling tower manufacturer but not less than that indicated on the Drawings.

2.8.3 Execution

2.8.3.1 Installation

(1) Installation shall follow the instruction manual from the manufacturer.

2.8.3.2 Testing and Commissioning

(1) Operating test run shall be provided from manufacturer.

(2) Prior to the operation of the water treatment system, the piping shall be flushed until the water runs clear.

2.9 FAN AND BLOWER

2.9.1 General

2.9.1.1 General Requirement

(1) The Private Party shall furnish and install the fans including all necessary accessories as specified herein.

(2) Requirements of fans in this section shall be applied to those which are not integral parts of air-handling units and similar equipment designed as complete units by the manufacturer. Fans shall be guaranteed to deliver the specified air quantities at the specified pressures. In addition, they shall be quiet in operation and be free from objectionable vibration. Each fan shall be suitable in size for the space available and be installed without damage to either the building or the fan.

(3) The rotation of the fan shall be checked on start up and if there is no rotation arrow supplied by the manufacturer, the Private Party shall provide correct rotation arrow.

(4) V-belt drives shall be dimensioned for long belt life according to the manufacturer's recommendations regarding belt tension, minimum pulley diameter and belt speed. For belt selection purpose, the actual motor horse power rating shall be multiplied by 1.3. A minimum of 2 belts shall always be provided. These belts shall be of the oil-resistant type. Belt drives shall have adequate means for adjustment of belt tension. Belt drives outside casings shall be protected with easily detachable belt guards.

2.9.1.2 Standards and References

(1) The fan and blower shall comply with the following codes and standards:

(a) ANSI/ASHRAE 51-1999 : Laboratory Methods of Testing Fans for Aerodynamic Performance Rating (AMCA Standard 210-99) (ANSI approved)

(b) ANSI/ASHRAE 87.1-1992 : Method of Testing Fan Vibration -- Blade Vibrations and Critical Speeds (ANSI approved AMCA)

(c)	ASHRAE 68	:	Laboratory Method of Testing In-Duct Sound Power Measurement Procedure for Fans.
(d)	ANSI/AFBMA 9	:	Load Ratings and Fatigue Life for Ball Bearings.
(e)	AMCA 300	:	Reverberant Method for Sound Testing of Fans.
(f)	AMCA 301	:	Method for Publishing Sound Ratings for Air Moving Devices.
(g)	SMACNA	:	HVAC Duct Construction Standards.
(h)	NFPA 90A	:	Standard for the Installation of Air-Conditioning and Ventilating Systems
(i)	UL 793/705	:	Power Ventilators for Smoke
(j)	UL 762	:	Power Roof Ventilators for Restaurant Exhaust Applications, (UL 762)
(k)	IEC 60034-1	:	Rotating Electrical Machines - Part 1: Rating and performance
(l)	BS 7346-5:2005	:	Components for smoke and heat control systems. Functional recommendations and calculation methods for smoke and heat exhaust ventilation systems, employing time-dependent design fires. Code of practice

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

2.9.1.3 Submittals

(1) The contraction shall submit fan and blower's performances selection, material list and technical data request for approval.

(2) Dimension plan and elevation view drawing or the unit, required cleanses, and location or all field ducting and electrical connections.

2.9.1.4 Warranty

(1) All parts or fan and blower shall be guaranteed by the Private Party and/or by the manufacturer at least two years after handover.

2.9.2 Material

2.9.2.1 Description

(1) Fan and all parts thereof shall be capable of satisfactorily withstanding the effect of all stress and loads under starting, operating and where applicable reversing conditions.

(2) Belt driven fan shall be selected, where as possible, fan shall be driven by motor with revolution less than 1,500 rpm.

(3) Unless specified, maximum noise level for all fans shall be less than 65 dB (A) measured at three times of fan diameter from the fan outlet.

(4) Fan and Blower's performance curve shall have certified rating by AMCA or DIN standard.

2.9.2.2 Component

(1) Centrifugal Fan

(a) Large fan housings shall be made in sections small enough to permit installation or removal through openings available in the building. Field joints shall be flanged and bolted. The fan scroll shall be attached to the side plates by means of continuous lock seam or welded seam construction. Intermittent spot welded type construction will not be acceptable. Thickness of steel plate for housings shall not be less than those indicated in the following table:

Wheel Diameter (mm.)	Housing Thickness (mm.)	
	Side	Scrolls
Not over 500	1.9	1.9
Between 500 and 1,000	2.0	1.9
Between 1,000 and 2,000	2.0	2.0

(b) Wheels shall be accurately assembled from die-formed parts and shall operate at all speeds, up to 1 1/4 times the maximum speed specified without noticeable static or dynamic unbalance, eccentricity or wobble. They shall be rigidly braced to resist torsional stresses due to air pressure and rapid acceleration.

(c) Shafts shall be steel, heavy enough so that the critical speed of wheels and shafts will be not less than twice the maximum speed. Shafts and wheels shall be tightly fitted and securely keyed.

(d) Bearings shall be self-aligning of the ball on roller type. Inner races of ball and roller bearing shall be secured to the shafts by press fittings, split taper sleeves, eccentric locking rings or set screws. Taper sleeve mounts shall be carefully adjusted so that bearings can neither slip on shafts nor be preloaded. Eccentric locking rings shall be securely tightened and retained by setscrews. The bearings held only by setscrews shall have two in each race and the screws shall have points designed to provide in locking action on the shaft.

(e) Where taper sleeves, eccentric locking ring or set screw-held bearings are furnished, the actual shaft diameters at the bearing shall not be different from the nominal bearing bores by more than the amounts indicated in the following table of tolerances :-

Shaft Diameter (mm.)	Tolerances(mm.)	
	Plus	Minus
Not over 25	0	0.013
25 to 65	0	0.025
75 to 100	0	0.038
125 and over	0	0.051

(f) Load ratings of ball and roller bearings shall be based on an average bearing life of not less than 200,000 hours, allowance being made for dead load of wheel, shaft and maximum pull of belts. Bearings requiring grease lubrication shall be equipped with readily accessible filling connections.

(g) Fan handling air that is abnormally hot or corrosive shall have both bearings opposite the inlet and overhung wheels and sheaves.

(h) Unless otherwise specified, double- and single-inlet fans having wheels larger than 900 mm. in diameter shall have two bearings, one on each side of the wheel, with overhung sheaves. Single-inlet fans with wheels not over 900 mm. diameter may have bearings arranged as specified for larger fans, or bearings may both be located on the side opposite the inlet with both wheels and sheaves overhung. Small wheels may be mounted on extended motor shafts wherever fan speeds permit.

(2) Axial Flow Fan

(a) The fan shall be belt-driven or direct driven, axial-flow fan with adjustable airfoil blade. The impeller shall be statically and dynamically balanced before coupling and shall be fixed on a shaft. Fan shaft shall be of high carbon steel. The motor shall be totally enclosed fan cooled three-phase induction.

(b) The fan casing shall be made of structural steel and designed to reduce resistance loss at each section. For high static pressure application, guide-vanes shall be welded inside the casing in order to obtain better fan efficiency. The motor terminal shall be connected by a steel pipe to a terminal box outside the casing, which keeps the lead wire completely isolated from draft.

(c) Consideration shall be given to noise-protection when using axial flow fans in public areas.

(3) Wall Mounted Propeller Fan

(a) Unless otherwise specified, propeller fans may be either direct-connected, motor driven type or belt-connected. They shall be quiet in operation and be statically and dynamically balanced. Wheels shall be steel, aluminum or plastic with heavy hubs.

(b) The gravity shutters shall be provided, opened in operation and closed in stopping. The blades of gravity shutter are weather-proof materials.

(c) The fan casing shall be made of steel, aluminum or plastic structure. The rubber sheet shall be inserted between fan casing and wall, for vibration isolator.

(d) The Private Party shall be block-out the wall during building construction period to comply with fan's casing dimension.

(4) Ceiling Type Fan

(a) The fan shall be specifically designed for mounting at ceiling only and shall be easily taken-off for maintenance without dismantling of the connected exhaust duct.

(b) Each fan shall consist of centrifugal fan, discharge gravity damper, tightly-sealed motor and baked enamel casing.

(5) Pressurized Air Fan

(a) Pressurized air fan shall be centrifugal fan or axial air fan.

(b) The motor driven for pressurized air fan shall be direct driven.

(c) The power supply for motor shall be for essential load, and cable shall be fire resistant (FR) type.

(d) Motor insulation shall be class F, protection IP55.

(6) Smoke Extract Fan

(a) Smoke extract fan shall be centrifugal fan, up-blast roof fan or axial air fan.

(b) The motor driven for smoke extract fan shall be direct driven. Belt driven shall not acceptable.

(c) The power supply for motor shall be for essential load, and cable shall be fire resistant (FR) type.

(d) Motor insulation shall be class H, protection IP55, conforming BS 7346 Class D, which can be operated at temperature 250 C for 1 hour.

(e) All parts of smoke extract fan including motor, fan driven, control and power supply shall be heat resistant conforming to BS 7346 Class D, which can be operated at temperature 250 C for 1 hour.

2.9.3 Execution

2.9.3.1 Installation

(1) Fans shall be mounted on or suspended with rubber-in-shear vibration isolators. These isolators shall be selected and installed in accordance with the unit manufacturer's recommendation so that no disturbance is caused in the surroundings.

2.9.3.2 Testing and Commissioning

(1) Before start-up, grease or lubricating oil shall be applied to the blower and motor.

(2) After installations are completed, all equipment shall undergo test run. Any adjustments that are needed shall be made to assure that all equipment will operate either the required performance. Report forms to contain following minimum data listings shall include design and actual conditions for each Item mentioned below:

(a) Date and time of test

(b) Fan make, type, name and serial number.

(c) Fan rpm

(d) Fan discharge static pressure

(e) Fan motor amperage

(f) Rated motor amperage, starter number and ampere rating

(g) Exhaust air CFM

2.10 AIR PURIFIER

2.10.1 General

2.10.1.1 General Requirement

(1) All air handler shall be installed with air purifier at downstream side of the unit.

(2) The air purifiers are devices or equipment that used to cleaning air for indoor air quality in the air conditioning system. The air purifiers are Pre-filter, Medium filter, Gas & odor filter and including Electronic air cleaner.

(3) For commercial fan coil unit which have capacity not exceed 17.6 kW. (60,000 Btu/Hr) or exposed type, used standard air filter from manufacturer.

2.10.1.2 Standards and References

(1) The air purifier shall comply with the following codes and standards.

(a)	NFPA 90A	:	Standard for the Installation of Air Conditioning and Ventilating Systems.
(b)	UL 900	:	Test Performance of Air Filter Units.
(c)	ASHRAE 52-76	:	Method of Testing Air Cleaning Devices used in General Ventilation for Removing Particulate Matter.
(d)	ASHRAE 62-89	:	EPA Ambient-Air Quality Standards for Outdoor Air

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

2.10.1.3 Submittals

(1) The Private Party shall submit air purifier's performance selection, material lists and technical data request for approval.

2.10.1.4 Warranty

(1) All materials shall be guaranteed by the Private Party and/or by the manufacturer for at least two years after handover.

(2) In the period of warranty, the Private Party shall conduct periodic maintenance with involves checking of filter necessary cleaning every 1 month.

2.10.2 Material

2.10.2.1 Description

(1) The unit shall be supplied with filter and accessories.

(2) The electronic air cleaner shall be supplied with all parts of the unit including electrical power unit and pre-wiring.

2.10.2.2 Component

(1) Pre Filter

(a) The pre filter shall be of cleanable corrugated aluminum filter or cotton and synthetic media pleat filter. The frame is constructed of high wet strength moisture resistant board.

(b) The offered pre filter shall be selected in accordance with the following requirements listed below:

(i) Filter media shall have an average arrestance of 65-80 % efficiency conforming to ASHRAE 52-76.

(ii) Maximum face velocity 2.54 m/s. (500 ft/min)

(iii) Approximate initial pressure drop 4.0 mm. (0.16 in.) WG.

(iv) Approximate final pressure drop 6.0 mm. (0.24 in.) WG.

(v) Approximate depth 100 mm. (4 in.), 50 mm. (2 in.), 25 mm. (1 in.) and 20 mm. (3/4 in.)

(c) Pre filter for small fan coil unit shall be 20 mm. thick, and have average arrestance not less than 65% efficiency.

(d) Pre filter for large air conditioning unit shall be 50 mm. thick, and have average arrestance of not less than 80% efficiency.

(2) Medium Filter

(a) The medium filter shall be extended surface pleat filter. The filter media is made of fine glass fibers.

(b) The offered medium filter shall be selected in accordance with the requirements given in the following:

(i) Filter media shall have and average dust spot efficiency of 80-85% conforming to ASHRAE 52-76.

(ii) Maximum face velocity 2.54 m/s. (500 ft/min)

(iii) Approximate initial pressure drop 11.0 mm. (0.45 in.) WG.

(iv) Approximate final pressure drop 22.0 mm. (0.90 in.) WG.

(v) Approximate depth 300 mm.

(vi) The filter shall be U.L. Class 2 when tested according to U.L. standard 900

(3) Gas & Odors Filter

(a) The gas & odors filter shall be side access filter housing constructed of 16 gauge galvanized steel with flush metered and welded corners. The housing shall contained slide track for the mating modules and gasket to air seals.

(b) The housing is equipped with two access door that are sealed with gaskets on the perimeter. The doors are equipped with easy grip positive sealing knobs.

(c) The standard 50 mm. (2 in.) pre filter track and the gas & odors tray track are made of extruded aluminum or galvanized steel and are gaskets to air seals.

(d) The gas & odors filter tray shall contain of Activate Carbon and Aluminociligate compound. The compound is impregnation with Potassium Permanganate not less than 4% by weight.

(e) The pressure drop through the filter shall not exceed 12 mm. (0.47 in.) WG.

(f) The weight of gas and odor filter shall be calculated for approval prior to installation.

(4) Filter Frame

(a) An air filter combination, as a filter bank, shall be mounted on the standard frame of the air filter.

(b) The stiffener shall be provided in order to increase the strength of the filter frame. The stiffener shall be as recommended by the manufacturer.

(c) Air filter frame selection shall take into consideration the type of air filter, locations and accessibility after installation has been completed. No air leakage shall occur at any joint of the filter frame.

(5) Electronic air cleaner

(a) The Private Party shall furnish and installed electronic air cleaners in accordance to this specification.

2.10.3 Execution

2.10.3.1 Installation

(1) The pre filter or air filter for air handling unit shall be 50 mm. (2 in.) depth.

(2) The pre filter or air filter for fan coil unit shall not be less than 20 mm. (3/4 in.) depth.

(3) Air handling unit installed with medium filter shall consist of 50 mm. (2 in.) pre filter and 300 mm. (12 in.) medium filter in the 600 mm. (24 in.) filter housing depth.

(4) Air handling unit installed with gas & odors filter shall consist of 50 mm. (2 in.) pre filter and standard gas & odors filter not more than 750 filter housing depth.

2.10.3.2 Testing and Commissioning

(1) All air purifier shall be tested in conjunction with the air moving equipment such as Air handling unit and ventilation fans.

(2) During the warranty period of gas and odor filters, dust particle shall be collected every 4 months for laboratory characteristic test in order to determine performance of filter and increase appropriate quantity if required.

2.11 PIPING WORKS

2.11.1 General

2.11.1.1 General Requirement

(1) The Private Party shall furnish and install all piping work including all necessary parts to completed work.

2.11.1.2 Standards and References

(1) The piping work shall comply with the following copes and standards.

(a)	ASTM A53/A53M-04a	:	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
(b)	ASTM B75-02	:	Standard Specification for Seamless Copper Tube.
(c)	ASTM B88	:	Seamless Copper Tube for Water, Gas and Sanitation
(d)	BS 2871 Part 1	:	Copper Tube for water, gas and Sanitation
(e)	ASTM C177	:	Steady State Heat Flux measurements and Thermal Transmission Properties by mean of the Guarded Hot Plate Apparatus
(f)	ASTM C534	:	Perform flexible elastomeric cellular thermal insulation in sheet and tubular form
(g)	BS 874 Part 2	:	Determining thermal insulating property part 2. Test for thermal conductivity and related properties

(h)	DIN 52615	:	Determination of water vapor (moisture) permeability of construction and insulation materials
(i)	ASTM D1056 Type 1	:	Flexible cellular materials-Sponge or Expanded Rubber
(j)	ASTM E96	:	Water Vapor Transmission of Materials
(k)	ASTM E84	:	Surface Burning Characteristic of Building Materials
(l)	ASTM D635	:	Rate of Burning and/or Extend and Time of Burning of Plastics in the Horizontal Position
(m)	UL 94	:	Flammability of Plastic Materials for Parts in Devices and Appliances

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

2.11.1.3 Submittals

(1) The Private Party shall submit all materials, catalogue, material lists and technical data requested for approval before installation.

2.11.1.4 Warranty

(1) All part of the piping work shall be guaranteed by the Private Party for at least two years after handover.

2.11.1.5 Delivery, Handling, Storage and Cleaning

(1) Pipes shall be delivered and stored with plugged ends. Ends shall be kept closed with temporary covers during erection.

(2) Before any pipe is installed, it shall be opened and pounded to remove any foreign substances, or swabbed, if necessary, for thorough cleaning.

(3) Pipes shall be stored on racks in a suitable warehouse or under cover to avoid rusting. If necessary, carbon steel pipes shall be coated with anodized rust converter or red lead primer.

(4) During the course of installation, the Private Party shall take every precaution to prevent any debris from being left in the pipes. He shall be responsible for any damage that may occur.

(5) Immediately after erection, exposed threads at all fittings shall be painted with zinc-chromate paint, and after welding each joint shall be wire-brushed and then painted with zinc-chromate paint.

(6) Before start-up all piping systems shall be thoroughly flushed with water until it runs clear.

2.11.2 Material

2.11.2.1 Description

(1) The valves shall be the types or models, which are suitable for the working fluid in the system. The rated working pressure of the valve as specified for the working fluid shall be at least 1.5 times of the actual working pressure, but not less than 1,034 kPa (150 PSIG.).

(2) The diameter of hand wheels for valves shall be of a suitable size so as to allow tight closure by hand with the application of reasonable force so that neither additional leverage nor damage shall be imposed upon the stem, seat and disc. Where indicated or required, for inaccessible overhead valves, chain-operated hand wheels including rustproof chain and chain guide shall be provided.

2.11.2.2 Component

(1) Chilled Water/Condenser Water Piping

(a) All pipes shall be seamed black steel pipes, conforming to ASTM A-53, Schedule 40. All pipes shall be welded joints and flanged connection for equipment and part required maintenance.

(b) Small pipe if necessary threaded joints may be used with union connection for equipment and parts required maintenance.

(c) Pipes and fittings shall be rated at not less than 1,034 kPa. (150 PSIG) working pressure.

(2) Make-Up Water/Drain/Condensate Drain Piping

(a) All pipes shall be galvanized steel, BS Standard class medium, or conforming to Thai Industrial Standard TIS 277-2521 medium weight.

(b) Threaded joints may be used for pipes of 50 mm. in diameter or smaller and flanged connections for pipes of 65 mm. and larger.

(3) Refrigerant piping

(a) Refrigerant pipe shall be copper tube hard drawn type L, conforming to BS 2827, part 2, fully annealed and internally degreased and creamed.

(b) Compression fitting will not be accepted on refrigerant pipe work.

(c) Screw joints will not be accepted in refrigerant pipe work except on the equipment accessories.

(4) Pipe insulation

(a) The insulation shall be closed cell structure, elastomeric thermal insulation, moisture and vapor barriers, self-extinguishing with fire and low smoke density while burning.

(b) Properties of Insulation shall be as the following:

(i) Thermal conductivity shall not be more than 0.038 W/m./K (0.26 BTU/Hr/ft^2/ $^\circ$F/Inch.) at 24°C (75°F) by test method of either ASTM C177, BS 874

(ii) Water absorption shall not be more than 5 percentage by weight method of ASTM C534 or ASTM D1056 Type 1

(iii) Water vapor permeability shall be <0.10 perm-in in compliance to ASTM E96

(iv) Moisture Resistance shall be ≥5,000 μ in compliance to DIN 52615

(v) Flammability shall be 25 in compliance to ASTM E84 or Class V-0 in compliance to UL94 or surface spread of flame of Class 1 in compliance to BS476 Part 7. Smoke density shall be 50 in compliance to ASTM E84

(vi) Density shall be 48-96 kg/cu.m. (3-6 lbs/cu.ft.)

(vii) Service temperature shall be -20°C to 105°C (-4°F to 220°F)

(b) The insulation shall be preformed tube or rolled sheet. The thickness of pipe insulation shall be as follows:-

Pipe Diameter (mm.)	Insulation Thickness (mm.)
65 (2 ½”) and smaller	32 (1 ¼”)
80 (3”) to 150 (6")	38 (1 ½”)
200 (8”) and larger	50 (2”)
Chiller Unit	38 (1 ½”)
Chilled Water Pump	32 (1 ¼”)
Condensate Drain 80 (3”) or less	13 (1/2”)
Condensate Drain above 80 (3”)	20 (3/4”)
Refrigerant Pipe	25 (1”)

2.11.3 Execution

2.11.3.1 Installation

(1) General piping installation

(a) All piping shall be installed parallel to, or at right angle with, the building walls and partitions. A pitch in the direction of flow and drain shall be not less than 1 : 500, in general. Branches from water mains shall be taken in a manner that facilitates venting and draining. Reductions in bore shall be formed eccentrically to facilitate venting, except on vertical pipes where concentric reduction may be used.

(b) All water piping shall be installed in such a way that all circuits can be completely drained off and all air pockets in the water circuits shall be suitably vented.

(c) Clearance between pipe works and equipment or machinery shall be adequately provided to facilitate maintenance. Overhead clearance shall be at least 600 mm. over access ways, and where possible the projection of valve stems into access ways shall be avoided. Pipe works and pumps shall be so arranged that the removal for maintenance of the equipment can be carried out with minimum dismantling. Provision of all pipe fittings and accessories necessary for the efficient functioning of the various systems shall be included.

(d) Pipes shall be installed in continuous lengths as long as possible. Except where required to be connected to fitting outlets or headers, they shall be jointed by welding, solvent welding, screwing or soldering as approved or indicated in this Specification.

(e) All pipe crossing structural expansion joint between buildings shall be provide with flexible connection.

(f) All pipes shall be installed in an appropriate manner to present a neat and orderly appearance, using fittings for all changes of direction, and arranging pipe runs parallel to or at right angles with structural members of the building, to provide uppermost head-room and to clear lights and other obstructions. In general, suspended pipes shall be installed as closely as possible to the overhead structure.

(2) Workmanship

All pipes shall be cut accurately to measurements established at the site, and shall be worked into place without springing or forcing. Piping shall be installed so that it may expand and contract freely without damaging to itself or other work. Steel and wrought-iron pipe shall be cut with pipe cutters and threaded with sharp, clean dies. All cut sections shall be reamed to remove all burrs and to restore the pipe to full diameter. All changes in size shall be made with reducing fittings. Pipe bending and bushings are prohibited.

(3) Location of device

All valves, equipment, accessories, and devices shall be so located that they are accessible for repair and replacement.

(4) Connections to equipment

Connections to coils, pumps and other equipment shall be made in such a manner that undue strains between pipes and equipment are eliminated. Unions and/or flanges shall be used to facilitate the removal of the equipment.

(5) Expansion and Contraction

(a) The piping systems shall be installed so that there will be no damage due to expansion and contraction during operation.

(b) Pack less type expansion connectors shall be used where the expansion and contraction of the pipe is excessive or cannot be compensated by expansion loops or offsets.

(6) Differential Settlement

The piping systems shall be installed so that there will be no damage due to differential settlement of the pipe supports after installation. The problems shall be avoided by providing flexible connections, offsets, or loops.

(7) Sleeves

(a) Vertical pipes passing through floors shall be provided with sleeves of anti-corrosion painted black steel pipes. Sleeves shall be of a proper length to pass through the entire floor construction all shall terminate 40 mm. above the finished floor level.

(b) Horizontal pipes passing through walls and partitions shall be provided with full thickness sleeves made of standard weight anti-corrosion painted black steel pipes.

(c) Sleeves shall be large enough to leave not less than 10 mm. clearance around the pipe or covering insulation, if there is any. Sleeves shall be set in place when the walls and partitions are built.

(d) Sleeves in concrete work shall be flanged at the bottom or provided with temporary centering caps and securely nailed or screwed to form work before the concrete are poured.

(e) Chromium-plated escutcheons shall be provided where exposed pipes pass through walls or floors.

(f) When sleeves are installed through a fire wall, the clearance between sleeves and pipes shall be filled with fire-resistant material. The fire rating of the fire-resistant material shall be at least equivalent to that of the fire wall.

(g) When pipes pass through waterproof walls, water retaining rings with approved type of sealant shall be applied.

(8) Pipe Joints

(a) Flanged joints shall be installed at all valves larger than 50 mm. and at other places where necessary. Jointing flanges shall be accurately parallel to each other so that bolts are used only to tighter joints, rather than correct alignment.

(b) Flanges shall be chosen to suit the maximum working pressure of the system at the points of installation in accordance with the ASME standards. They shall be manufactured from a similar material to the pipe works and fittings to which they are to be attached.

(c) Jointing materials used between flanged faces shall be of 3.2 mm. thick gaskets of good quality or shall be of suitable material for the specified working fluid. Machined steel bolts with hexagonal heads and nuts, and fitting with cadmium-plated flat steel washers where necessary. For bronze flanges, machined brass bolts with hexagonal heads and nuts shall be used.

(d) The maximum length of each bolt shall be such that when it is fixed on the joint with nut in position, it shall not extend more than 1/4 of its diameter beyond the nut while the minimum length shall be a full nut. All threaded connections shall be made tight with an approved pipe thread compound or Teflon tape. They shall be so jointed that not more than two threads will be exposed. Union joint faces shall be smeared with graphite and oil during connection.

(e) The edges of the pipe to be welded shall be machine-beveled wherever possible. Gas cuts shall be free from burnt metal. Before welding, the surface shall be thoroughly cleaned and degreased. The welding technique shall be such as to ensure penetration to the full thickness of the pipe wall and through fusion of the deposited metal with the parent metal. During welding the ends of the pipes shall be held firmly together by suitable lugs, welded-on-bridge pieces or adequate tack welding. Special care shall be taken to prevent formation of welded obstructions and lodgment of welding residue inside the pipes. Cracks, pinholes, excessive under cutting, etc. shall be removed and the joints rewarded. Welding materials and workmanship shall be in accordance with acceptable standard.

(f) Welders must be competent and shall have qualification certificates. They may be required to perform site tests. Should the Engineer's Representative not be satisfied, the welder must be replaced? The Engineer's Representative reserves the right to order the cutout for inspection of up to 1 per cent of the total number of welds. In the event of any inspected welds being, in the Engineer's Representative's opinion, unsatisfactory he reserves the right to order the removal of further welds which in his opinion indicate faulty workmanship. Welds removed for inspection shall be reinstalled.

(g) Either the electric arc or the oxy-acetylene welding method may be used for metallic pipes. Welding rods or electrodes shall have such composition that the welds produced by them shall have the same analysis as the parent metal and shall be of an approved type and brand.

(h) Prior to silver-soldering or brazing (if any) suitable chemical shall be used in cleaning the metal surface to be jointed in order to remove oil and grease. Scale and any gross oxidation shall be removed by emery cloth, or grinding. Care shall be taken in preparation of the joints.

(i) All tees or take-off's shall be made with standard welding fittings only.

(9) Pipe Hangers and Supports

(a) Hangers or supports shall be provided at intervals as shown on specified herein, both in horizontal and vertical runs. In addition, it is required that a hanger be provided at not more than 1.0 meter (3.5') from each change of direction on the side of the longest run and also at point adjacent to all valves, strainers, etc. All hangers and supports for horizontal piping shall be adjustable in height over a minimum distance of 50 mm. (2") the intervals indicated for support are maximum distances between brackets.

(b) For chilled water and condensate piping, rigid insulation of minimum length of not less than the outside diameter of the insulation shall be provided at each support and hanger.

(c) For all pipes where the hanger clips bear directly on pipes and for hanger of dissimilar metals suitable separation with a layer of felt shall be provided to prevent corrosion. Hangers on structural steel must be clamped in position with hook bolts. Drilling holes in or welding to structural steel is absolutely prohibited, unless with the express approval from the Engineer's Representative.

(d) Anchors for steel pipes shall be welded directly to the pipe wall and securely bolted to the building structure. Anchors for copper and PVC pipes shall be of the split ring type. Hangers in the main technical room shall be supported on springs.

(e) Supporting brackets shall be fastened to concrete by means of inserts or expansion bolts, to brickwork by means of expansion bolts, and to hollow masonry by means of toggle bolts.

Two fixings per bracket shall be provided at follows :-

Nominal Pipe Size (mm.)	Fixing Size (mm.)
Up to 65 (2 ½")	6.4 (1/4")
80 (3") to 150 (6")	9.5 (3/8")
200(8") to 350 (14")	12.7 (1/2")

(f) All hanger and steel shall be hot-drip galvanized.

(g) For all pipes hangers in the plant room shall be provided with spring isolators to reduce noise transmission to adjacent rooms. The spring shall be selected to maintain 25 mm. (1”) minimum static deflections.

(10) Pipe insulation

(a) The outer surface of the pipe shall be cleaned before installation without any cement or small particles attached to the pipe surface that may cause uneven surface. The irregular uneven surface on the joint area should be made smooth.

(b) Installation shall use the adhesive recommended by insulation manufacturer. Apply the adhesive on the joints then press the joints together tightly. The joints shall be made level and smooth without tilt. For insulation on equipment, adhesives shall be applied on both insulation and equipment surface. The insulation shall fit into the equipment smoothly without air holes or bubbles inside.

(c) Installation shall be in the standard length according to the manufacturer. Then install it by slipping continuously onto the pipe and joints. In case that it cannot be slipped, the insulation has to be slit along the tube length and then closed back firmly by adhesives.

(d) After installation, the insulation shall be in the right tension, not too loose or too tensed, observable by its appearance. Shall not use perform tube that is bigger than the pipe size.

(e) For hanging, holding and other method to support the pipe shall use polymeric rigid foam pipe supporter to prevent the weight pressure on the insulation. The rigid foam pipe supporter shall have equal or similar thermal conductivity as the insulation and shall be in a full or half circular shape in order to support the full pipe or only the bottom part of the pipe on the load supporting point.

(f) Insulation materials that are improperly stored, damaged, torn, scratch, unclean shall not be used for installation.

(g) After installation, it shall be covered with another layer of anti-rust metal sheet (aluminum sheet, galvanized steel sheet, stainless sheet) with thickness at least 0.5mm for the following areas:

(i) Chilled water pipes that are located on the ground in the pant room.

(ii) Vertical or horizontal chilled water pipes that may be easily damage.

2.11.3.2 Testing and commissioning

(1) Water piping shall be tested with water pressure of not less than 1034 kPa. (150 Psig) or 1.5 times the maximum working pressure, whichever is greater, at the lowest point in the system. Care shall be taken to avoid putting excessive pressure on safety devices, etc. These delicate control mechanisms shall be removed during the tests to prevent shock damage. The system shall be tested when water temperatures and average ambient temperatures are approximately equal and constant. Test pressure shall be maintained for not less than 30 minutes without an appreciable drop after the force pump has been disconnected.

(2) Piping may be tested a section at time in order to facilitate the construction.

(3) Leaks in screwed fittings shall be corrected by remaking the joints. Leaks in welded joints shall be cut out and re-welded. Caulking of leaks will not be permitted.

(4) After pressure tests have been made, the entire water-distribution system to be sterilized shall be thoroughly flushed with water until all entrained dirt and mud have been removed before introducing chlorinating material. The chlorinating material shall be either liquid chlorine or hypochlorite. The chlorinating material shall provide a dosage of not less than 50 PPM. and shall be introduced into the system in an approved manner. The treated water shall be retained in the pipe long enough to destroy all nonspore-forming bacteria. Except where a shorter period is approved, the retention time shall be at least 24 hours and shall produce not less than 10 PPM of chlorine at the extreme end of the system of the retention period. All valves in the system

being sterilized shall be opened and closed several times during the contact period.

2.12 VALVES AND PIPING ACCESSORIES

2.12.1 General

2.12.1.1 General Requirement

(1) Shut-off valves shall be furnished as necessary for a satisfactory operation of all apparatus.

(2) Valves of the same type shall be supplied by the same manufacturer.

2.12.1.2 Standards and References

(1) The valves and accessories shall comply with the following codes and standards:

(a)	ASTM A53/A53M-04a	:	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
(b)	ASTM B75-02	:	Standard Specification for Seamless Copper Tube.
(c)	TIS 277-2521	:	Steel Pipes
(d)	ASME/ANSI B16	:	Standards of Pipes and Fittings
(e)	ASME Section VIII	:	Pressure Vessels; Boiler and Pressure Vessel Codes
(f)	ANSI/NEMA 250	:	Enclosure for Electrical Equipment

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

2.12.1.3 Submittals

(1) The Private Party shall submit all valves and accessories performance selection, catalog, material lists and technical data for approval before installation.

2.12.1.4 Warranty

(1) All parts of valves and accessories shall be guaranteed by the manufacturer and/or by the Private Party for at least two years after handover.

2.12.2 Material

2.12.2.1 Description

(1) The valves shall be the types or models, which are suitable for the working fluid in the system. The rated working pressure of the valve as specified for the working fluid shall be at least 1.5 times of the actual working pressure, but not less than 1,034 kPa (150 PSIG.).

(2) The diameter of hand wheel for valves shall be of a suitable size so as to allow tight closure by hand with the application of reasonable force so that neither additional leverage nor damage shall be imposed upon the stem, seat and disc. Where indicated or required, for inaccessible overhead valves, chain-operated hand wheels including rustproof chain and chain guide shall be provided.

2.12.2.2 Component

(1) Ball Valves

(a) Valves shall be of ball pattern with stainless steel ball and square head type, valves for chilled water system shall have extended stem for valve insulation purpose.

(b) Ball valves shall be used for sizes up to 50 mm. (2”) and shall be made of bronze with threaded ends.

(2) Gate Valves

(a) Gate valves shall be used for shut-off water flow in pipe. The rated of pressure shall be at least 1,034 kPa (150 PSI.)

(b) Valve size 50 mm. (2”) and smaller shall be bronze body, solid wedge disk, non rising stem and screw in bonnet.

(c) Valve size 65 mm. (2.1/2”) and larger shall be cast iron body, solid wedge disk, rising stem and flange end.

(3) Globe Valves

(a) Valves of sizes up to 50 mm. (2”) shall be bronze with threaded ends, solid wedges and non-rising stems.

(b) Valves of size 65 mm. (2.1/2”) and larger shall be cast-iron with flanged ends, solid wedges and non-rising stems.

(4) Silent Check Valves

(a) Silent-type check valves shall be installed at the location where noise and water hammer would cause a problem. The valve shall be of a spring closed type. Seats, discs, and springs shall be bronze or stainless steel.

(b) Valves of sizes up to 50 mm. (2”) shall be bronze with threaded ends.

(c) Valves of sizes 65 mm. (2.1/2”) and larger shall be cast-iron with flanged ends.

(5) Automatic Balancing Valves

(a) Automatic Balancing Valves for AHU with a capacity not over 12 kW.

The valves shall consist of dynamic accessible, flow limiting device. They shall automatically maintain a constant water flow rate through the cooling within + 5% of rated flow. In the fully open position and at rated flow rate the pressure drop through valves shall not be more than 40 kPa (14’ water). The valves shall withstand an operating pressure not less than 1,034 kPa (150 PSIG). Flow regulation cartridge and spring shall be stainless steel and readily accessible for change out or maintenance. Body shall be bronze for valve size 40 mm. (1.5”) and smaller and shall be cast iron for valve size 50 mm. (2”) and larger.

(b) Automatic Balancing Valves for AHU with a capacity over 12 kW.

The Automatic Balancing Valves shall automatically maintain a constant water flow rate through the cooling within + 5% of rated flow. They shall work in harmony with the 2-way control valves. They shall not work against the 2-way control valve during modulation. In the fully open position and at rated flow rate the pressure drop through valves shall not be more than 40 kPa(14’ water). The valves shall withstand an operating pressure not less than 1,034 kPa (150 PSIG). Flow regulation part and spring shall be stainless steel and readily accessible for change out or maintenance. Body shall be cast iron.

(6) 2-Way Motorized Control Valves

(a) The 2-way control valves shall be motorized with a feedback control from thermostat with a signal of 2-10 VDC or 4-20 mA. The valves shall be returned to close position by spring or other method when AHU are not working.

(b) 2-way motorized valve proportional type shall be used for AHU capacity over 12 kW. which have been mentioned in item Automatic Balancing Valves.

(c) 2-way motorized valve on-off type shall be used for AHU capacity not over 12 kW. Pressure drop through fully open valves shall not be over 15 kPa (2 PSI.). The valves shall withstand an operating pressure not less than 1,034 kPa (150 PSIG). They shall be returned to close position by spring or other method when AHU are not working. The closed off rating shall not be less than the actual system required.

(7) Butterfly Valves

(a) A butterfly valve can be used instead of a gate valve if its size is over 50 mm. It shall have flange bolt centering holes for easy installation and be drilled to suit precisely the piping flange. The valve shall be able to shut off the system even the pipe on one side has been removed. The body shall be cast-iron with aluminium-bronze disc of sufficient rigidity and strength to resist distortion. The stem shall be through shaft design to provide high strength and positive disc control.

(b) Compound rubber seat rings shall have excellent elasticity as well as wear resistance to ensure positive water shut-off under the designed working pressure. Moulded-in " O " rings shall provide positive flange sealing to eliminate need for gaskets. All rubber parts shall be of the type suitable for the specified working fluid. Lever operated valves shall be used for sizes up to 150 mm. (6”) Gear-operated valves shall be used for sizes larger than 150 mm. (6”) Position indicators shall be provided to indicate valve disc position.

(8) Pressure Relief Valve

(a) The Pressure Relief Valve is a hydraulically operated, single seated globe valve, controlled by a direct acting spring and diaphragm pilot valve. It is available in globe or angle body. The main valve is operated by the line pressure passing through the pilot system. It will relief when the line pressure is over the requirement pressure.

(i) Pressure ratings : 1,034 kPa. (150 PSI.)

(ii) Pressure adjust ranges : 170 to 550 kPa. (25 to 80 PSI.)

(iii) Materials

- Main Valve : Cast iron
- Body & Bonnet : Cast iron
- Seat : Stainless Steel
- Stem : Stainless Steel
- Diaphragm : Reinforced Synthetic Rubber

(9) Flexible Pipe Connections

(a) Flexible connections at inlets and outlets of chillers and pumps shall be of neoprene rubber impregnated fabric reinforcement, bellow shape with flanged ends. The flexible connectors shall be designed for excellent vibration and noise protection. Isolated tension members shall be provided to prevent excessive elongation.

(b) Flexible connections shall be suitable for the specified working fluid or specified working pressure and temperature.

(10) Expansion Joints

(a) Packless construction externally pressurized guide expansion connectors shall be used where the expansion and contraction of the pipe is excessive or cannot be compensated by expansion loops or offsets.

(b) Anchors and pipe guides shall be provided and installed at the recommended locations.

(c) All expansion connectors shall have flanged ends with working pressure corresponding with the piping system.

(11) Strainers

(a) Water strainers shall be of the Y type. Strainers of 50 mm.(2”) and smaller shall have bronze or iron bodies with screwed connections while 65 mm.(2.5”) strainers and larger shall have iron bodies and flanged connections. They shall have the same rating as the piping system.

(b) A Water strainers shall comply with the requirements of the ASTM standards.

(c) Screens shall be of stainless steel with perforating as follows :-

Strainer		**Perforation**	
mm.	**(inches)**	**mm.**	**(inch)**
20 to 50 inclusive	(3/4”-2”)	0.76	(1/32”)
65 to 150 inclusive	(2.1/2”-6”)	1.52	(1/16”)
200 to 300 inclusive	(8”-12”)	3.05	(1/8”)
Over 300	(12”)	6.10	(1/4”)

(d) The free area of each screen shall be not less than three times the area of the strainer inlet pipe. Strainers of 65 mm. (2.5”) and larger shall be provided with 15 mm. (1/2”) valve drains.

(12) Water/Air Vent and Drain

(a) Manual air vent shall be furnished as required for purging air or other gases from the water circuit during filling up. The outlet shall be piped to the nearest drain.

(b) Automatic air vents, conforming to ASA Standards, shall be of cast-iron body furnished at the top of main water risers, supply and return pipes.

(c) A shut-off valve shall be provided at all low points of pipe work systems.

(d) Drains shall be installed to ensure easy access and convenience for maintenance and removal of all piping, valves, fittings and equipment without undue spillage.

(e) Drainage facilities shall be provided and suitable sized to drain expeditiously the entire system and equipment involved.

(13) Thermometers

(a) Thermometers shall be of the adjustable angle glass tube-type in a 230 mm. case with the stem of 90 mm and accuracy of ± one scale division. The scale range shall be suitable for the specified working fluid temperature.

(b) Thermometer wells shall be designed to hold an engraved stem thermometer. Wells shall be made of stainless steel or of equivalent material. They shall be project as much as possible into the pipe at the most suitable location for accurate measurements and readings. The thermometer well welding socket shall be supplied as one of the packages.

(14) Pressure Gauges

(a) Pressure gauges shall be of the bourdon type, stainless steel casing, round type of 100 mm. (4”) dial and scale range of approximately 150 per cent of the normal operation. Pressure readings shall be in PSI. and/or Pascal.

(b) A needle shut-off valve and pressure snubber with working pressure corresponding with the piping system shall be provided.

(c) Oil filled pressure gauges shall be selected where there is an excessive vibration.

(15) Closed Type Expansion Tank

(a) General

The expansion tank for air-conditioning system shall be of closed type with diaphragm. The tank shall be constructed of mild steel and tested conforming to ASME standard. The rated working pressure shall be not less than 1,034 kPa. (150 PSIG). The tank shall be painted conforming to the Specification. The outside of tank shall be insulated with 25 mm. (1 inch) thick of closed cell flexible foamed plastic insulation.

(b) Control Accessories

The tank and pressure control accessories shall be installed as manufacturer recommendation and shall consist of:

(i) Isolating valve

(ii) Pressure relief valve

(iii) Pressure gauge

(iv) Strainer

(v) Check valve

(vi) Bypass valve

(vii) Two-way motorized valve

(ix) Limit pressure control

(16) Flow Switch

(a) Flow switch shall detect the flow of water in pipeline. The detector shall be insert through a hole in pipe and connected by a mechanical linkage to the delay mechanism. The construction shall be watertight, dust-tight and corrosion resistant in a compact size. It should be suitable for use in areas of high humidity. All detectors shall be UL list.

(i)	Wetted parts	:	Brass
(ii)	Switch enclosure	:	NEMA 4X
(iii)	Pressure rating	:	1,034 kPa. (150 PSI)

(iv) Minimum Temp. rating : 0o C (32o F)

(v) Maximum Temp. rating : 104o C (220o F)

(vi) Electrical : 10A 250 VAC

(17) Variable Frequency Drive (Inverter)

(a) Control Specification

(i) Control Method : Sinusoidal pulse width modulation (PWM)

(ii) Voltage control

(iii) Frequency Range : 6-60 Hz

(iv) Start Frequency : 3 Hz

(v) Frequency Accuracy : ± 0.5% At 25°C ± 10°C

(vi) Over current Capacity : 150% for one minute

(vii) Frequency Setting Signal : 4-20 mA. DC.

(viii) Acceleration/Deceleration Time : 10-150 Sec.

(b) AC Input 380V/3 Phase/50 Hz., ± 5% for frequency fluctuation, ± 10% for voltage fluctuation.

(c) Protective-Function

(i) Over-current stall prevention

(ii) Regenerative over-voltage stall prevention

(iii) Over-current protection

(iv) Regenerative over-voltage protection

(v) Overload protection

(vi) Ground fault protection

(vii) Instantaneous power failure protection

(viii) Overload alarm

(ix) Harmonic arrester or protection against interfering to other electronic/ sensors

(x) Ambient operating temperature of 50°C

2.12.3 Execution

2.12.3.1 Installation

(1) Installation of equipment and accessories shall be in compliance to the manufacturer's recommendation.

2.12.3.2 Testing and Commissioning

(1) All equipment and its accessories shall be test run by the manufacturer and/or Private Party. Cleaning is required prior to test run.

2.13 DUCT WORKS

2.13.1 General

2.13.1.1 General Requirement

(1) Unless otherwise specified or noted, casings, plenum chambers and ducts shall be of zinc-coated sheet steel of varying thickness and construction as specified.

(2) The construction of ductwork shall be generally in accordance with the "Duct Manual and Sheet Metal Construction for Ventilating and Air-conditioning System", published by the Sheet Metal and Air-conditioning Contractors National Association Inc.

(3) In ducts, the slip joint must form a smooth interior surface and a neat exterior appearance. All joints shall be as near airtight as possible. All seams shall be continuous around four sides of the duct. Under no conditions shall hangers or supports piece the ducts. All curves, vents, offsets, etc. are to be made for an easy flow of air with minimum obstruction and the radius being not less than the width of the duct or flue.

(4) All changed in dimensions and shapes of ducts shall be gradual with a slope of not less than 1 to 4.

(5) Changes in duct size or shape that may interference with other works shall be made by using the size of the equivalent friction loss.

(6) Where space permits, elbows shall have an inner radius of at least the duct width measured in the plane of the elbow. Where shown or where required to fit in restricted space, square elbows shall be used. These elbows may be constructed with square inner and outer corners, and shall be fitted with factory-made or shop-fabricated turning vanes. Factory-made turning vanes shall be zinc-coated or factory-finished with black enamel or other suitable finish. Seams, joints and bracing of elbows shall be as specified for straight ducts.

(7) Splitter dampers shall be provided for air adjustment in throats at all duct branches. Rivets, screws and other fastening details shall be made of or plated with the same metal as the ducts or other metals having equal or superior corrosion-resistance.

(8) The exposed air ducts in air conditioning area except that in technical room shall be painted with high quality coloring paint conforming to specification of "Painting". Colors shall be selected by the Engineer's Representative.

(9) Where ducting passes through walls and floors, the area between the frame and the ducting shall be covered on both sides of the wall by boards of 20 mm. (3/4") thick multiplex, neatly cut to form a sound barrier. The space between the covering board shall be filled with rockwool to a maximum density. All joints shall be sealed with mastic.

(10) Small holes, 50 mm. (2") in diameter with cover plates, are to be provided for the use of Pilot tubes for measurement of air quantities. Such holes are to be provided at convenient positions to facilitate regulation of all branches and as may be required by the Engineer's Representative.

(11) In the technical rooms, the ducting shall be fabricated in flanged sections, bolted together with cadmium-plated bolts and nuts and asbestos cord for easy dismantling.

(12) Bracing angles shall be provided for all sides and riveted to the ducts at 150 mm. (6") centre to centre. Bracing angles, angle flanges and transverse joints shall be painted with 2 coats of antirust paint.

2.13.1.2 Standards and References

(1) Duct works shall comply with the following codes and standards.

(a)	SMACNA -	:	HVAC Duct Construction Standards, Metal & Flexible, 1995, 2nd Edition
(b)	SMACNA	:	Fire, Smoke & Radiation Damper Installation Guide for HVAC Systems, 5th Edition
(c)	SMACNA	:	HVAC Duct Systems Inspection Guide, 2nd Edition
(d)	SMACNA	:	Accepted Industry Practice for Industrial Duct Construction Handbook
(e)	SMACNA	:	Fibrous Glass Duct Construction Standards
(f)	SMACNA	:	HVAC Systems - Duct Design Manual
(g)	SMACNA 1286	:	Fire, Smoke & Radiation Damper Installation Guide for HVAC Systems
(h)	Standard 68-1997	:	Laboratory Method of Testing to Determine the Sound Power in a Duct (AMCA Standard 330-97) (ANSI approved)
(i)	Standard 126-2000	:	Method of Testing HVAC Air Ducts (ANSI approved) (SMACNA standard)
(j)	Standard 120-1999	:	Method of Testing to Determine Flow Resistance of HVAC Ducts10and Fittings (ANSI Approved)
(k)	UL 555 Revision 2	:	Fire Dampers

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

2.13.1.3 Submittals

(1) The Private Party shall submit all material selection, catalog, material lists and technical data for approval before installation.

2.13.1.4 Warranty

(1) All parts of duct works shall be guaranteed by the manufacturer and/or by the Private Party for at least two years after handover.

2.13.2 Material

2.13.2.1 Description

(1) The construction of ductwork shall be generally in accordance with the "Duct Manual and Sheet Metal Construction for Ventilating and Air-conditioning System", published by the Sheet Metal and Air-conditioning Contractors National Association Inc.

2.13.2.2 Component

(1) Low Pressure Duct

(a) Low pressure ducts shall be used where static pressure does not exceed 50 mm. water gauge.

(b) Low pressure ducting shall be constructed with galvanized steel sheet and steel bracing angles in which the thickness and dimension of the respective equipment shall not be less than the indicated figures for low pressure ducting in the latest edition of ASHRAE and/or SMACNA.

(c) Sheet metal for slips and drive caps shall be of the same material and thickness as the ducts.

(2) Medium Pressure Duct

(a) Medium pressure ducts shall be used where static pressure is higher than 50 mm. water gauge, but not over 100 mm. water gauge.

(b) Medium pressure ducting shall be constructed with galvanized steel sheet and steel bracing angles in which the thickness and dimension of the respective equipment shall not be less than the indicated figures for medium pressure ducting in the latest edition of ASHRAE and/or SMACNA.

(c) Medium pressure ducts shall be constructed without sharp edges or irregularities that may generate noise.

(3) Spiral Duct

(a) Spiral duct shall be constructed with galvanized steel sheet. The construction and thickness of spiral duct shall conform to the latest edition of ASHRAE and/or SMACNA.

(b) Spiral duct shall be constructed with smooth inside surface with low friction loss.

(4) Round Flexible Duct

(a) The flexible ducts shall be made of a coated polyester fabric, the outside of which shall be mechanically interlocked by a corrosion-resistant metal spiral helix. If specified, factory-applied insulation shall be a nominal 25 mm. (1") thick, 24 kg/m3 (1.5 lb/ft3) density fiberglass. The vapour barrier shall be of fiberglass fabric coated with a black elastomer compound and laminated to aluminized polyester film. Pressure rating is 300 mm. of water static.

(5) Duct Support and Hangers

(a) Horizontal rectangular/round, low and medium pressure ducts shall be supported by hangers.

(b) A pair of hangers shall be located close to each transverse joint and elsewhere as required by the spacing indicated in table of air duct hanger.

(c) Upper ends of hangers shall be vertical and secured individually to floor of above roof construction. Hangers shall not be secured to suspended ceilings, suspended ceiling hangers or insertions to which suspended ceiling hangers are attached.

(d) The hangers and supports shall be of the adjustable type and hot-dip galvanized.

(6) Access Panels

(a) Access doors shall be installed in casings, plenum chambers and ducts where shown and wherever else required for ready access to dampers and other operating parts of any kind.

(b) Access doors shall be 1 mm. thick, double-skin set in galvanized frames with 25 mm. (1”) thick, 48 kg/m3 (3 lb/ft3) density fiberglass insulation and approved latches and hinges. Edges and frames shall be stiffened and made airtight with felt strip. The minimum size shall be 300 by 300 mm. except ducts less than 300 mm. where minimum size shall be 150 by 150 mm (6”x6”)

(7) Flexible Collars

(a) Flexible collars shall be provided at the connections between fans and ducts or casings, where required to prevent expansion joints. They shall be approximately 200 mm. (8”) long and shall be installed with just sufficient slack to prevent transmission of vibration.

(b) Circular collars shall be secured to fans and ducts with metal bands of 2 mm. (0.08”) thick and 25 mm. (1”) wide. Rectangular collars shall be secured to ducts and fans with 25 mm. by 3.2 mm. (1” by 0.125”) flat bars fastened with screws or bolts at 200 mm. (8”) intervals or with flanges similar to those specified for duct joints. Metal for fastening collars shall be the same as specified for ducts and bracing.

(c) Flexible collars shall be constructed of fire-resistant flexible canvas, or neoprene-coated glass fabric.

(d) Collars for ducts operating at temperatures above 40oC (104oF) and acid-resistant ducts shall be made of neoprene-coated polyester fabric.

(e) Collars exposed to weathering shall be made of neoprene-coated glass fabric.

(8) Dampers

(a) Automatic Air Dampers

(i) Automatic dampers shall be of the air balancing type, with flat or elliptical steel blades, mounted horizontally in welded steel frames. Blades shall have interlocking edges. Rectangular dampers of 300 mm. or more in a direction perpendicular to the axis shall be louvered. Blades on louvered dampers must not be over 200 mm. wide. Round dampers shall be single-blade dampers. Damper blades shall have steel turnings mounted in bronze sleeve bearings or ball bearings. Dampers between bearing shall be not more than 150 mm. long. Opposed blade dampers shall be similar to louvered dampers except that the air stream is not deflected to one side. Where volume control is required, opposed blade dampers shall be used.

(ii) Dampers shall guaranteed to close substantially tight. Those for use in high pressure and high velocity systems shall be of special design to minimize noise. Dampers in outdoor air intakes, discharge openings and mixing dampers on hot and cold air plenum systems shall have fitted edges or neoprene rubber edges cemented and riveted in place during fabrication. Rectangular dampers having an area larger than 0.4 m^2 (4 ft^2) shall have additional corner bracing.

(iii) Damper operating links shall be steel or brass rod, adjustable in length and of such proportions that they will withstand without appreciable deflection a load equal to not less than twice the maximum operation force of the damper motor. Joints in linkages shall be made with steel or brass pins or with ball and socket joints of ample size. Steel parts of damper shall be finished with two coats of enamel or aluminum paint or shall be zinc-coated.

(b) Volume Dampers

(i) All dampers necessary for proper control and balance of air distribution for ductwork systems shall be furnished and installed so that they can be adjusted at any time after the completion of the Works.

(ii) Front and back bars or vanes of direction grilles are not to be used for adjustment of all quantities.

(iii) Generally, butterfly dampers shall be of the air balancing type with flat or elliptical blades. Blades shall be rigid, with close fitting hem edges. A damper in ducts over 350 mm. (10ft) in minimum dimension shall be of the multiple opposed blade type. Multiple blades shall be not over 300 mm. (12”) wide and may be either gang-operated or individually operated. Blades of dampers in medium and high pressure ducts shall be non-metallic or provided with non-metallic edges or coating.

(iv) Damper rods shall be not less than 9.5 mm. (0.375”) squared at one end and shall either pass entirely through the ducts or shall be of short stubs secured to the blades by not less than 2 bolts or rivets at each end. The squared end of each rod shall be held in lever type locking device with a central locking nut of large diameter or a quadrant and locking screws. Ends of damper rods in medium and high pressure ducts shall be provided with means of sealing them to prevent leakage of air.

(v) Dampers shall have frames of not less than 50 mm. (2”) wide and blades of 1.6 mm. (0.0625”) galvanized steel. The damper plate shall be pivoted on a rod or installed with hinges, controlled with one or more rods that are fastened to the leading edge of the blade. Damper rods, on the other hand, shall be not less than 9.5 mm. in diameter and slip through a hub fastened to the duct side. The setscrew in the hub holds the rod and damper to a desired setting. Length of damper blades shall be at least equal to the width of branch. The damper blades, pivots and rods must be rigid in installation so that they will neither vibrate nor create noise.

(c) Fire Dampers

(i) The fire dampers shall be constructed according to NFPA 90A and UL-555, the fire rating shall have the same fire rating as the wall through which is to be led.

(ii) The casings and blades of fire dampers shall be constructed of zinc-coated steel. The casing shall be flanged and supported by the fire wall or floor and be totally independent of the ducting in which they are incorporated.

(iii) Damper blades shall be pivoted off-balance and counter-weighted so that they can be closed by gravity, but held open by approved, rigid, fusible links.

(iv) Links shall be set at 71°C (160°F) heat resistance for horizontal ducts and 40°C (120°F) for vertical ducts. Access doors shall be provided at each fire damper and shall be 600 by 600 mm. (24”x24”) except ducts less than 300 mm. (12”), in which case the sizes shall not be smaller 150 by 150 mm. (6” by 6”)

(v) All parts of fire damper (Frame, damper and fusible links) shall be tested and certified by UL-555

(d) Fire and Smoke Dampers

(i) The fire and smoke damper shall be constructed according to NFPA 90A and UL555S, the fire rating shall have the same fire rating as the wall through which is to be led.

(ii) The casings and blades of fire dampers shall be constructed of zinc-coated steel. The casing shall be flanged and supported by the fire wall or floor and be totally independent of the ducting in which they are incorporated.

(iii) The dampers shall be automatically closed when either smoke concentration or temperature above safety limit. Any remote sensors, wiring and accessories shall have the same fire rating as the dampers.

(iv) All parts of fire and smoke damper (Frame, damper, actuator and fusible links) shall be tested and certified by UL-555S

(9) Duct Silencer and Duct Liner

(a) The Private Party shall be responsible for installing the necessary duct silencer or duct liner to reduce the transfer of sound (created by the fan) to the rooms. The sound level from the air handling unit and fan coil unit measure in an occupied room shall not exceed NC 40 for public spaces and NC 45 for back of the house, unless otherwise specified.

(b) Duct Silencer shall be constructed to suit the ducting or the air handling units in which they will be incorporated. The duct silencer shall be built-up of a casing in which sound absorbing cells are fitted.

(c) Casings shall be made of zinc-coated steel, not lighter than specified herein for ducts of the same outside dimensions, but in no case lighter than 0.76 mm. for low pressure ducts and 1 mm. for medium pressure ducts. Casings shall be suitable braced and sealed so as not to show any distortion or leakage.

(d) Duct silencer lining materials shall neither impart odor to the air nor delaminate readily. There shall be no loose material on any exposed surface that may be detached by the air stream, either during installation or under regular operating conditions. The materials shall be non-combustible. Sound absorbing materials in contact with the air stream shall be neoprene-coated. All lining materials shall be in good condition at the time of final inspection. Material damaged in shipment by rough handling, vibration or exposure will be rejected. It shall be replaced or coated to prevent detachment of loose material as directed by the Engineer’s Representative.

(e) Duct silencer lining materials shall be adequately secured and protected. Edges of materials that are not protected by metal shall be heavily coated with an adhesive to prevent detachment of loose materials, whether such edges are to be exposed in the finished assembly or butted against other similar edges.

(f) Duct liner shall have the construction of 25 mm. fiberglass 48 kg/m3 density and coated with neoprene.

(10) Black Steel Sheet Duct

(a) All hot air exhaust duct from kitchen shall be constructed of minimum 2.0 mm (0.08 inch) thick black steel sheet. All duct joints shall be welded and each duct section shall be fabricated in flanged connection.

(b) The kitchen exhaust duct shall be insulated with 40 mm (1 1/2 inches) calcium silicate and covered with aluminum foil vapour barrier same specification and for fiberglass insulation. Where exposed, the duct shall be covered with galvanized steel sheet jacket instead of aluminum foil vapour barrier.

(c) The kitchen exhaust duct shall be sloped in 1:500 and appropriate 25 mm (1 inch grease drain cocks shall be provided.

(11) Miscellaneous Exhaust/Duct Work

(a) Dedicate kitchen dishwasher and laundry iron shall use welded stainless steel exhaust duct which is slope back to equipment for drainage of condensation and ducted directly to outside.

(b) Fabricate pool bromine/chlorine storage room exhaust duct from stainless steel.

(12) Duct Smoke Detector

(a) All duct smoke detectors shall be provided for all air handling units. Detectors shall be photoelectric type and listed by Underwriters Laboratory, UL

(b) The duct detector shall operate at air velocities from 1.52 mps. (300 fpm.) to 20.3 mps. (4000 fpm.). Housing shall be of metal construction and complete mechanical installation will be performed without removal of detector cover.

(c) Visual indicator of alarm and power must be provided on detector front. A manual reset switch shall be located on front of the device. Terminal shall be provided for remote alarm indication, strobe/horn and remote reset switch. All wiring must comply with local codes and regulation.

(13) Air Outlet

(a) All ceiling diffusers, registers and grilles shall be of the size and shapes which is depended on air flowrate, air outlet velocity and noise level. Noise level shall be complied to ASHRAE standard.

(b) Diffusers shall be constructed of anodized, extruded aluminum. Sharp edges and corners shall be ground-off and the surface shall be flush-finished.

(c) Opposed blades volume control dampers shall be provided with each diffuser. All accessories shall be constructed of extruded aluminum, and assembled without any metal-to-metal contact in moving parts. The opposed blades volume control damper shall be adjusted without removing any part of air outlet.

(d) All internal parts of each diffuser shall be removable as a unit to permit cleaning of the diffuser and provide access to the ducts. All diffusers shall be supported independently from the suspended ceiling system and shall be of an adjustable type.

(e) Registers shall be nylon-fitted, noise proof, 4-way adjustable anodized, extruded aluminum grille with opposed blade volume control damper. All registers shall have gaskets, installed and located in place without glue, blades mounted in nylon self-lubricating bashing, and assembled without any metal to-metal contact in moving parts.

(f) Return, transfer and exhaust air grilles shall be constructed of extruded anodized aluminum. All blades shall be mounted in rigid vinyl insert cushion elements to prevent rattling or vibration.

(g) Fresh air grilles shall be similar in construction to return and exhaust grilles. They shall always be equipped with opposed blade volume dampers and insect screens.

(14) Duct insulation

(a) Duct insulation shall be fiberglass of 24 kg/m3 (1.5lb/ft3) density and shall be with factory applied, reinforced " Fire resistant " aluminum foil vapor barrier. The vapor barrier facing material shall consist of double sided of aluminum foil reinforced with kraft paper and fiberglass yarn mesh. The insulation shall meet the requirement of NFPA 90A. Fire hazard classification and flame spread rating for insulating and acoustic material, vapour barrier, covering and wrapping materials permanently attached or installed separately shall not exceed 25 and the smoke developed rating not exceeding 50, when testing with ASTM specification E84.

(b) Duct insulation thickness shall be as follows specified below :

Duct Location	Thickness, mm (inch)
Supply air duct outside air conditioning space or return air stream	50 (2”)
Supply air duct in air conditioning space and return air duct outside air conditioning space	25 (1”)

2.13.3 Execution

2.13.3.1 Installation

(1) All supply and return air ducts for cooled air distribution shall be insulated. Return air duct in air conditioning space, fresh air and exhaust air ducts may not be insulated.

(2) Flanges and other steel parts shall be painted prior to the application of insulation.

(3) The insulation blankets shall be adhered to the ducts by applying fire resistant adhesive over the outside area of the ducts.

(4) The connection of insulation blankets or joints shall be overlapped and sealed with at least 65 mm. (2.5”) wide of the aluminum adhesive tape. Before applying the tape, surfaces should be cleaned to remove moisture, oil, grease, and dirt. A 10-mm.(3/8”) wide aluminum belt shall be provided (over insulation blanket) around the ducts at a spacing of approximately 600 mm.(24”).

(5) In order to protect the insulation from damage, insulated ducting shall be supported on strips of hard wood or gypsum board of 6 mm.(0.25”) thick and 150 mm.(6”) wide at all supports and hangers.

(6) In case of size duct over 300 mm (12”), mechanical clip and washer shall be provided in every 300 mm. (12”) interval.

2.13.3.2 Testing and commissioning

(1) High pressure blower with control damper shall be used for test apparatus. Air for testing shall be introduced into the system through a suitable filter and dryer to exclude all impurities.

(2) A flow measuring device shall be of an orifice assembly consisting of straightening vanes and an orifice plate mounted in a straight tube with properly located pressure taps. Each orifice assembly is accurately calibrated with its own calibration curve, which shall also be submitted to the Engineer’s Representative for approval. Pressure and flow readings shall be taken with U-tube manometers.

(3) Test procedures shall be of audible test with a pressure of 50 mm WG in excess of designed duct operating pressure. All joints for audible leaks shall be surveyed and each leak shall be marked and repaired after shutting down the blower. After all audible leaks have been sealed, the orifice section with a pressure of 25% in excess of designed duct operating pressure.

(4) Total allowable leakage shall conform to the first edition of "HVAC Air Duct, Leakage Test Manual" of SMACNA standard. When partial sections of the duct system are tested, the summation of the leakage for all sections shall not exceed the total allowable leakage.

2.14 AIR DISTRIBUTION DEVICES AND ACCESSORIES

2.14.1 General

2.14.1.1 General Requirement

(1) All air distribution devices shall be of the size which is depended on air flowrate, outlet air velocity and noise criteria.

(2) Type of air distribution devices shall be selected via application of function and shall be approved by Engineer's Representative.

2.14.1.2 Standards and References

(1) Air distribution devices and accessories shall comply with the following codes and standards.

(a)	SMACNA	:	HVAC Duct Construction Standards, Metal & Flexible, 1995, 2nd Edition
(b)	SMACNA	:	Fire, Smoke & Radiation Damper Installation Guide for HVAC Systems, 5th Edition
(c)	SMACNA	:	HVAC Duct Systems Inspection Guide, 2nd Edition
(d)	SMACNA	:	Accepted Industry Practice for Industrial Duct Construction Handbook
(e)	SMACNA	:	Fibrous Glass Duct Construction Standards
(f)	SMACNA	:	HVAC Systems - Duct Design Manual
(g)	Standard 68-1997	:	Laboratory Method of Testing to Determine the Sound Power in a Duct (AMCA Standard 330-97) (ANSI approved)
(h)	Standard 126-2000	:	Method of Testing HVAC Air Ducts (ANSI approved) (SMACNA standard)

(i) Standard 120-1999 : Method of Testing to Determine Flow Resistance of HVAC Ducts10and Fittings (ANSI Approved)

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

2.14.1.3 Submittals

(1) The Private Party shall submit air distribution device's performance selection, catalog, material list and technical data request for approval before installation.

(2) The Private Party shall provide samples or material for air distribution device request for approval before installation.

2.14.1.4 Warranty

(1) All air distribution devices shall be guaranteed by the Private Party for at least two year after handover.

2.14.2 Material

2.14.2.1 Description

(1) The air distribution devices is the device used for distributed the air to the space.

2.14.2.2 Component

(1) Supply Ceiling Diffusers (SCD.)

(a) Supply ceiling diffusers shall be 1 to 4 ways air direction. The diffusers shall be square shape or rectangular shape.

(b) The diffusers shall be constructed or extruded anodized aluminum, removable cones and installed flush-finish with the ceiling. (flush mount) .

(c) All diffusers shall have opposed blade volume control dampers, which can be adjusted air volume without removing the diffusers.

(2) Supply Air Registers (SAR)

(a) Register shall be 4 walls adjustable air direction supply air registers shall be constructed of extruded aluminium and shall have an individual adjustable blade place one up on the other (vertical front blade and horizontal rear blade).

(b) All registers shall have opposed blades volume control dampers white can be adjusted air volume without removing the registers.

(3) Supply Air Grills (SAG)

(a) Supply air grilles shall be constructed of extruded anodized aluminium and blades fixed on the grilles with 45° angle deflection.

(b) All grilles shall have opposed blade volume control dampers which can be adjusted air volume with out removing the grilles.

(4) Supply Linear Slot (SLS.) / Return Linear Slot (RLS.)

(a) Supply linear slot shall be constructed of extruded anodized aluminium and shall be formed to provide horizontal air flow (condo air flow pattern). The linear slot shall be one-way or two-way flow direction and shall be complete with internal damper to adjusted air flow, flow direction and pattern. Each air flow channel shall not less than 20 mm.(314 in.) wide.

(b) Return linear slot shall have the same character as the supply linear slot, but the return linear slot does not have internal control damper.

(5) Return Air Grilles (RAG.)

(a) Return air grilles shall be constructed of extruded anodized aluminum and blade fixed on the grilles with 45° angle deflection.

(b) Return air grilles shall be of removals cores and installed flush-finish with the ceiling (flush mount).

(6) Transfer Air Grilles (TAG)

(a) Transfer air grilles shall be constructed of extruded anodized aluminium and horizontal blade fixed on grilles with 45° angle deflection.

(b) If on the wall, transfer air grilled shall have face and fixed grilles on both sides of the wall.

(7) Fresh Air Grilles (FAG.) / Outdoor Air Grilled (OAG.)

(a) Fresh air grille and outdoor air graces shall be constructed of extruded anodized aluminium and horizontal blade fixed on the grilles with 45° angle deflection.

(b) Fresh air grilles and outdoor air grilles shall be designed for outdoor type, which have ability to protect water come to inside of graces (wheat her proof).

(8) Exhaust Air Grilles (EAG)

(a) Exhaust air grilles shall be constructed of extruded anodized aluminium and horizontal blades fixed on the grilles with 45° angle deflection.

(b) Exhaust air grilles shall be designed for outdoor type, which have ability to protect watch come to inside of grilles (wheat her proof).

(9) Exhaust Air Registers (EAR)

(a) Exhaust air registers shall be constructed of extruded anodized aluminium and horizontal blades fixed on the grilles with 45° angle deflection.

(b) The exhaust air registers shall have opposed blade volume dampers on the back of the register, which can adjust air flow rate without removing the registers.

2.14.3 Execution

2.14.3.1 Installation

(1) The installation of diffusers, grilles and registers in the ceiling or on the walls shall be flush-finish.

(2) All diffusers, grilles and registers shall be installed with galvanized steel plenum.

2.14.3.2 Testing and Commissioning

(1) After installations are completed, all equipment shall be test run. Any adjustments that are needed shall be made to assure that all equipment will operate either the required performance.

2.15 AUTOMATIC CONTROL EQUIPMENT

2.15.1 General

2.15.1.1 General Requirement

(1) Automatic control systems shall include all dampers, valves, thermostats and other control devices. Control devices shall be connected complete so as to perform the indicated functions and operate in the required sequence.

(2) All control equipment shall be supplied by a firm whose establishment is widely recognized and whose engagement in the installation and maintenance of this control equipment is on a regular basis.

2.15.1.2 Standards and References

(1) The automatic control equipment shall comply with the following codes and standards.

(a)	ASHRAE 135-1995	:	BACnet® - A Data Communication Protocol for Building Automation and Control Networks
(b)	EN 50081-1	:	Generic Emissions: Residential, Commercial, and Light Industrial Environments
(c)	EN 50081	:	Electromagnetic Emissions - Generic Emissions Standard (3) NEC

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

2.15.1.3 Submittals

(1) The Private Party shall submit automatic control equipment's performance selection, catalog, material lists and technical data for approval before installation.

(2) The Private Party shall submit full detail of equipment, function of work, size and method of installation before the work starts.

2.15.1.4 Warranty

(1) All part of automatic control equipment shall be guaranteed by the Private Party and/or by the manufacturer for at least two year after handover.

2.15.2 Material

2.15.2.1 Description

(1) The quality and type of the instruments and enclosure shall be suitable for the climatic conditions of the area where they will be used according to the manufacturer's recommendation. Care should be taken in selection of instruments for hazardous areas, fire control purposes and outdoor use.

(2) All automatic control equipment shall be completed with automatic control function and can be interface to the building management system (BMS).

2.15.2.2 Component

(1) Electronic sensors and controllers

(a) Electronic equipment shall be of the unit type with all elements readily removable for testing and replacement. Equipment shall be enclosed in a suitable housing.

(b) Electronic sensor/controller shall be used to detect analogue signal (temperature humidity, etc.)

(c) Thermostats shall be of the proportional type unless two-position instruments are required in these Specifications or diagrams.

(d) In general, duct thermostat shall be of a remote sensor type. Sensing elements shall be located where they will respond to a representative temperature within the duct. Operating and adjusting mechanisms or controller shall be enclosed in metal or phenolic resin cases and shall be located on the outside of the ducts with covering. If the distance between the remote sensor and controller (operating/adjusting) panel exceeds the recommended maximum length, a remote transmitter, mounted on the outside of the duct, shall be used.

(e) Remote sensor shall be protected against damage. Capillary tubes or wires between sensor and operating mechanisms shall be protected by conduit, moulding or flexible armour. Excess capillary or wire lengths shall be neatly coiled and securely fastened out of the way. Capillaries or wiring shall pierce thermal insulation at the smallest practicable number of points. They shall be properly sealed wherever they pierce an insulation vapour seal.

(f) Pipe thermostats, generally, shall be of a remote sensor type. Pipe shall be provided with suitable socket or thermo-well for sensor. Where the distance between the sensor and controller (adjusting/operating) panel exceeds the recommended maximum capillary or wire length, a remote transmitter shall be used. Protection of capillary tubing and wires shall be as specified for duct thermostats.

(g) Room thermostats shall be securely attached to suitable bases mounted on the walls or other building surface. Each thermostat shall be located where shown or, if not shown where it will respond to the average temperature in the room. Thermostats, generally, shall be mounted with centerline 1.50 m. above the floor and shall not be mounted on outside walls or light partitions between offices if other locations are more suitable. Thermostats mounted on outside walls shall be provided with insulated bases.

(h) Room thermostats in which the adjusting mechanism is integral with the sensing element shall have locked or concealed adjustment devices by means of which the operating points can be adjusted through a range of not less than 5°C, above and below the operating points specified. External thermometers and knob or lever adjusting devices (lockable type) shall be furnished on room thermostats.

(i) Every electronic temperature control system shall be provided with one or more transformers to supply power for equipment operating at less than the normal lighting circuit voltage.

(j) Transformer shall be fed from the nearest air-conditioning switchboard.

(k) Control transformer shall have ample capacity to operate simultaneously all apparatus connected to it and shall be capable of carrying a 25 per cent overload. Transformers shall be of the open type with screw type terminals.

(l) Relay shall be of electronic or electric type and shall be totally enclosed. Capacity shall be suitable for the loads controlled and contacts shall be as specified for thermostats.

(2) Electric actuators and motors

(a) Controlled voltage shall be either 220V or 24V.

(b) Valve and damper motors shall be of the proportional or on off type in accordance with thermostat or controller and shall be quiet in operation. All motorized valves for air handlers shall be returned to close position when fan motors being turned off.

(c) Operating speeds of valve and damper motors shall be selected or adjusted so that the motors will remain in step with the controller without hunting, regardless of load variations. Motors operating in sequence with other motors shall have adjustable operating ranges and starting points to permit adjustment of the control sequence as required by the operating characteristics of the system.

(d) Damper motors may be mounted either inside or outside of the duct or casing. If install outside, they must be mounted on supporting plates that are completely outside the covering. On casings or ducts handling cold air, the supporting plates shall be installed in a manner that will prevent condensation on cold surface.

(e) Valve and damper motors shall be of rugged construction and quiet in operation. When operated at rated voltage, each motor shall be capable of delivering not less than twice the torque required by the valve or damper and shall withstand, without damage, continuous stalling.

(f) Motors shall function properly with a 10 per cent plus or minus change in line voltage supplying to the equipment.

(g) Motors shall be of either the hydraulic or geared type. Motor-driven pinions and high speed gears may be made of a suitable non-metallic composition to insure quiet operation, while others may be of steel or bronze. Shaft shall be hardened steel, running through bronze, hardened steel, nylon or other suitable sleeves or ball bearings. Lever arms shall be attached to motor shafts with setscrews or other secure and adjustable means.

(h) Motors and gear trains shall be totally enclosed in dustproof housing of pressed steel or cast metal with conduit entries. Gear trains shall be oil-immersed.

(i) Two-position motors shall be of the single direction, spring return (stall) or reversing type. Proportioning motors shall be of the reversing, shaded pole or capacitor induction type, capable of stopping at any point in the cycle and starting in either direction from any points. Reversing and proportioning motors shall have limit switches to limit the lever travelling in either direction. Every valve motor shall be equipped with a spring yield device so that, when in the closed position, it will maintain on the valve disc a pressure equivalent to that of the valve.

(j) Motor actuator shall be selected with sufficient close-off rating according to the actual system.

2.15.3 Execution

2.15.3.1 Installation

(1) Installation shall follow the instruction manual from the manufacturer.

2.15.3.2 Testing and Commissioning

(1) The Private Party shall require the control supplier to supervise and commission the control system. The testing for the automatic control system include the following service :-

(a) Prior to commencement of work on site:-

Advise on the operation of the control system, identification and correct positioning of control equipment and wiring connections.

(b) During the progress of the site work:-

Advise on the correct location and installation of controls and correct wiring on controls. Particular attention shall be paid to the mounting of actuators on valves, dampers, and the correct linkages form actuators to valves and dampers. The work shall be carried out on the basis of regular visits throughout the period of Phase I.

(c) When the installation is completed :-

Commission the complete control system supplied under this section of these Specifications to provide detailed operation and performance figures.

(2) Provide all normal servicing and maintenance during the Phase II – Operation and Maintenance for all equipment provided under this PPP Contract. In addition the following tests shall be carried out :-

(a) Insulation resistance

(b) Earthing continuity

(c) Polarity

(d) Continuity

(e) Phase proving tests to ensure that phases are connected in the specified manner and correct sequence throughout.

(f) Earth fault loop inspection test.

(3) Final commissioning of control systems after the Engineer's Representative's approval of the test records the systems shall be finally commissioned.

2.16 ELECTRICAL AND CONTROL WORKS

2.16.1 General

2.16.1.1 General Requirement

(1) This part of the Specification describes all electrical equipment and installations including connections thereof for the aforementioned system.

(2) The Private Party shall furnish and install all equipment and accessories for the electrical and control works as per scope of installation being finalized at the detail design stage which shall be approved by the Engineer's Representative.

(3) In general, the building services electrical works will be responsible for providing and installing power cabling onto Motor Control Centers (MCCs) and/or power distribution boards that are in scope of the mechanical works, and power cabling complete with terminal devices such as disconnecting switches, enclosed circuit breakers, junction boxes, etc. The mechanical works will be the provision and installation of equipment ongoing from the electrical works thereof.

(4) All items of a similar nature shall be products of one manufacturer.

(5) All equipment, wiring methods and the installation shall conform to the latest applicable standards as specified in this specification.

2.16.1.2 Standard and Reference

The electrical and control works shall comply with the following codes and standards.

(1)	IEC 60227-1	:	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V - Part 1: General requirements
(2)	IEC 60228	:	Conductors of insulated cables
(3)	IEC 60502-1	:	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1.2 kV) up to 30 kV (Um = 36 kV) - Part 1: Cables for rated voltages of 1 kV (Um = 1.2 kV) and 3 kV (Um = 3.6 kV)
(4)	IEC 60331-1	:	Tests for electric cables under fire conditions - Circuit integrity - Part 1: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0.6/1.0 kV and with an overall diameter exceeding 20 mm
(5)	IEC 60331-2	:	Tests for electric cables under fire conditions - Circuit integrity - Part 2: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0.6/1.0 kV and with an overall diameter not exceeding 20 mm
(6)	IEC 60331-11	:	Tests for electric cables under fire conditions - Circuit integrity - Part 11: Apparatus - Fire alone at a flame temperature of at least 750 °C
(7)	IEC 60332-1-1	:	Tests on electric and optical fibre cables under fire conditions - Part 1-1: Test for vertical flame propagation for a single insulated wire or cable – Apparatus

(8)	IEC 60332-3-10	:	Tests on electric and optical fibre cables under fire conditions - Part 3-10: Test for vertical flame spread of vertically-mounted bunched wires or cables – Apparatus
(9)	IEC 61034-2	:	Measurement of smoke density of cables burning under defined conditions - Part 2: Test procedure and requirements
(10)	IEC 60754-2	:	Test on gases evolved during combustion of materials from cables – Part 2: Determination of acidity (by pH measurement) and conductivity
(11)	BS 6387	:	Test method for resistance to fire of cables required to maintain circuit integrity under fire conditions
(12)	TIS 11-2553	:	Thai Industrial Standard for PVC insulated copper cables
(13)	ANSI/NEMA FB 1	:	Fittings, Cast Metal Boxes and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
(14)	ASTM A123/A123M	:	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
(15)	ASTM D1248	:	Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
(16)	NEMA ANSI C80.1	:	Electrical rigid steel conduit (RSC)
(17)	NEMA ANSI C80.3	:	Steel electrical metallic tubing (EMT)
(18)	NEMA ANSI C80.6	:	Electrical intermediate metal conduit (IMC)
(19)	IEC 61439-1	:	Low-voltage switchgear and controlgear assemblies - Part 1: General rules
(20)	IEC 61439-2	:	Low-voltage switchgear and controlgear assemblies - Part 2: Power switchgear and controlgear assemblies
(21)	IEC 60947-1	:	Low-voltage switchgear and controlgear - Part 1: General rules

(22) IEC 60947-2 : Low-voltage switchgear and controlgear - Part 2: Circuit-breakers

(23) IEC 60947-4-1 : Low-voltage switchgear and controlgear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters

(24) IEC 60947-7 : Low-voltage switchgear and controlgear - Part 7: Ancillary equipment

(25) IEC 60269-1 : Low-voltage fuses - Part 1: General requirements

(26) IEC 60269-4 : Low-voltage fuses - Part 4: Supplementary requirements for fuse-links for the protection of semiconductor devices

(27) IEC 61869-1 : Instrument transformers - Part 1: General requirements

(28) IEC 61869-2 : Instrument transformers - Part 2: Additional requirements for current transformers

(29) IEC 61326 : Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements

(30) IEC 61010-1 : Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements

(31) IEC 62053-21 : Electricity metering equipment (a.c.) - Particular requirements - Part 21: Static meters for active energy (classes 1 and 2)

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

(33) NFPA 130 : Standard for Fixed Guideway Transit and Passenger Rail Systems

(34) NFPA 70 : National Electrical Code

(35) EIT 2001-56 : Thai Electrical Code 2013

(36) MEA : Metropolitan Electricity Authority

In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

The standards and codes as mentioned above can be equivalent by another standards and codes, if it equal or better than the standards and codes mentioned when comply between two codes.

2.16.1.3 Submittals

(1) The material lists and technical data, Working Drawings, details of all material and equipment installations, and catalog shall be submitted to the Engineer's Representative for approval before purchasing and installation.

2.16.1.4 Quality Assurance

(1) The equipment manufacturer shall be ISO 9001 certified.

2.16.1.5 Warranty

(1) All parts of the electrical and control works shall be guaranteed by the Private Party at least two (2) years after handover.

2.16.2 Materials

2.16.2.1 Description

(1) The provision and installation of the equipment shall be based on the following electrical system:

(a) Rated Voltage : 415-Y/240V

(b) System Voltage : 380-Y/220V

(c) Rated Frequency : 50 Hz.

(d) Earthing System : TN-S (separate neutral and protective conductors throughout the system)

(2) All electrical conductors such as busbars, cables, wires, terminals, etc. shall be color-coded in compliance with EIT 2001-56 std. as follows:

(a) Phase A (R) : Brown

(b) Phase B (S) : Black

(c) Phase C (T) : Gray

(d) Neutral : Light Blue

(e) Ground : Green or Green-with-Yellow strip

(f) Large wires and cables and shall be color-coded with suitable heat shrinkable sleeves as the specified color.

(g) Busbars shall be color-coded with standard paint as the specified color.

2.16.2.2 Component

(1) Earthing (or Grounding) & Bonding

(a) The equipment grounding system shall be designed and installed such that all metallic, enclosures, raceway, junction boxes, outlet boxes, cabinets, machine frames, portable equipment, and other conductive items in close proximity with electrical circuits operate continuously at ground potential.

(b) The equipment grounding system shall provide a low impedance path for possible ground fault currents. The system shall consist of a separate green insulated equipment grounding conductor for each feeder and each branch circuit. The required grounding conductor shall be installed in the common conduit with the related phase and/or neutral conductors. Each electrical expansion fitting shall be provided with an external flexible braided ground strap securely bonded on each end of the fitting. The required equipment grounding conductors shall be sized in accordance with NEC - Table 250.122 or/and EIT 2001-56 Section 4 or other approved equivalent.

(c) Unless otherwise specified, the grounding connectors shall be of a type specifically manufactured for grounding purposes, made of copper alloy and assembled with high strength silicon bronze hardware. Where grounding or bonding conductors connect to structural cables, connections shall be made with mechanical devices; welded connections shall not be made at these points. All mechanical connections shall be completely encapsulated in non-hardening, conductive epoxy. The epoxy shall be applicable for wet locations or for ambient temperatures of 10 °C - 55 °C.

(d) Jumper material shall be flexible braided tinned-copper strap.

(e) Grounding of all chillers, pumps, and air handling units shall be done by means of separate green insulated equipment grounding conductor for each feeder or each branch circuit.

(2) *Motor Control Centers (MCC)*

(a) General Requirement

This provision covers the design and construction of motor control center of floor or wall mounting type. The equipment shall comply with the requirement in applicable standards of IEC as stipulated, or other standards as approved equivalent (or better).

(b) Electrical Characteristic

The electrical characteristic of the equipment shall be as follows:

(i)	Rates voltage	:	415V/240V
(ii)	System Wiring	:	3-Phase, 4-Wire with 33% Earth (ground)
(iii)	Rated Frequency	:	50 Hz.
(iv)	Rated Current	:	to be specified at the detailed design stage.
(v)	Rated Interrupting Capacity	:	to be specified at the detailed design stage. (I_{CU} and I_{CS} in kA_{rms})
(vi)	Insulation Class	:	600V (Minimum)
(vii)	Degree of protection	:	IP 31 (for Indoor), IP 55 (for Outdoor)

(c) The Construction of Motor Control Center

(i) Motor control center shall consist of two or more vertical sections bolted together to form a totally enclosed rigid construction. The vertical section shall be made of sheet steel (minimum thickness of 2 mm.). Each vertical section shall consist of three compartments viz. busbar, cable, terminal and control unit compartment which each compartment shall be separated by the standard steel sheet barrier. The motor control center shall be designed to permit easy addition and removal in the future.

(ii) Each control unit compartment shall be the combination of starter, circuit breaker and other accessories for each motor. The unit shall be completely enclosed and isolated from all other units. Unit side plates shall be permanently attached. Each unit shall have a single door mounted on removable hidden pin hinges. Each door shall be provided with a removable panel suitable for mounting push button, selector or switch and pilot lamp.

(iii) Efficient ventilation opening shall be provided on the panel. The opening shall be screened so as to be insect-proof.

(iv) Each panel shall undergo a treatment of degreasing and derusting by electro-galvanized or other equivalent method for anti-rust and shall be coated by an oven-baked enamel paint finished.

(v) All doors shall be provided with dust-protection gaskets of neoprene or any other approved material. All doors shall be equipped with locks operated by keys.

(vi) Plastic nameplate with engraved letters of at least 3 mm. thick shall be placed at ever circuit breaker and starter indicating their uses.

(vii) Mimic bus diagram shall be applied for each motor control center.

(viii) Uniform height and depth shall be adopted for the cubicles.

(d) Busbars and Busbar Holders

(i) The Busbars shall be 98% copper and shall be mechanically braced to withstand the maximum symmetrical short-circuit current rating of the main circuit breaker. The busbars shall have sufficient cross sectional area to continuously conduct rated full load current, as shown on the approved single line diagram, for operation in 35°C ambient temperature and for limit temperature rise within the requirements of IEC 61439-2. The current carrying capacity of the busbars shall be of the bare busbars rating conformed to IEC 61439-2.

(ii) Neutral and Ground busbar shall be equipped through the entire length of the cubicle.

(iii) A ground busbar sizing shall be not less than 33% of phase bus size.

(iv) All bolted bus jointed shall be silver plated or tin plated, and all joints shall be securely tightened to Manufacturer's standards for each size of hardware. Bolted, Nuts and Washers for buses connection shall be high tension class and the contact point between buses and terminal pad shall be electrical compound painted.

(v) Busbar holders shall be of fiber-glass reinforced polyester (FRP) type or Epoxy-resin (flame-proof material) or better. The calculation sheets and technical data, showing the minimum spacing between the busbar holders for withstand the maximum force caused by short circuit current, shall be submitted for approval.

(vi) Each busbar shall have colour identification conforming to the colour coding as stipulated.

(e) Moulded Case Circuit Breaker (MCCB)

(i) In general, all circuit breakers installed in the MCC shall be moulded case circuit breakers (MCCB) complying with IEC 60947-1 and IEC 60947-2 standard.

(ii) The MCCB shall be manually operated, quick–make, quick–break and trip-free for over-current and short circuit current, and have a common trip on all multi-pole breakers with internal tie mechanism. Drives shall be toggle operating mechanism, operated by trip-free system and shall have clearly indication whether the circuit breaker is “ON”, “OFF” or “TRIP”.

(iii) All MCCB shall be capable of being installed the additional devices such as shunt trip, under-voltage relay, auxiliary switch, alarm switch, rotary handle, pad locking device, etc to increase performance of the protection control.

(iv) The MCCB ampere frame rating ≤ 250 AF shall be thermal magnetic trip type and others shall be electronic trip type. Terminals of the MCCB rating ≤ 250 AF shall be cable lugs and the others shall be busbar terminals.

(v) Trip unit for the MCCB rating ≤ 250 AF shall be thermal-magnetic trip with adjustable thermal current from 0.7–1.0 time of rated Ampere-Frame (AF).

(vi) Trip unit for the MCCB rating ≥ 400 AF shall have rating plug to adjust ampere rating. The ampere rating can be adjusted from 0.1–1.0 time of rating plug for overload current, and 3-10 times of rating plug for short circuit current.

(vii) All circuit breakers rating ≥ 1000 AT shall be completed with ground fault sensor. The sensor shall have the following characteristic:

1) Ground-fault clearing time of main circuit breaker shall be more than the clearing time of feeder circuit breaker.

2) Ground fault pick-up current ≥ 200 A. (adjustable)

3) Time delay can be set at 0.1, 0.2, 0.3 and 0.4 Sec

(viii) All circuit breakers shall be equipped with rotary handles and pad locking facilities.

(ix) Main circuit breaker for the MCC shall be equipped with the following protective devices.

1) Phase sequence protection

2) Phase failure relay

3) Over and under voltage protection with time delay relay

4) Shunt Trip

(x) All circuit breakers shall be selected to perform in coordination pattern along the protective lines.

(f) Motor Starters

(i) Motor starters shall comply with the requirement in applicable standards of IEC as stipulated, or other standards as approved equivalent (or better).

(ii) Each starter shall be of an air break type and provided with thermal overcurrent trip unit (one on each phase). In case of intervention of the above trip units, an auxiliary contact shall release the starter coil off and give an alarm signal.

(iii) The thermal overcurrent trip units shall be of the manually reset type, and suitable push buttons shall be provided on the door of each unit.

(iv) At least 2 normally open and 2 normally closed free contacts for both starting and tripping signals shall be provided. These free contacts shall be wired to the terminal blocks for remote indicator.

(v) Contacts of the motor starter shall be able to withstand interrupting current ≥ 10 times of the rated current of motor.

(vi) Automatic direct-on-line (DOL) starters are allowable for various motor sizes up to 7.5 HP (5.5 kW) and closed circuit transition reduced voltage (or Y-Δ) starters shall be used for those over 7.5 HP (5.5 kW).

(g) Measuring Devices and Instruments

(i) All measuring devices and instruments shall comply with the requirement in applicable standards of IEC as stipulated, or/and other standards as approved equivalent (or better).

(ii) Multifunctional Digital Power Meter (DPM)

1) The DPM, if applied, shall be panel mounted type, complete with LCD or LED display unit. The display unit shall have the minimum 3 rows with 7 characters per row for value monitoring. The meter shall be in compliance with IEC 61326, IEC 61010-1 and IEC 62053-21 standard or other approved equivalent.

2) The DPM shall be able to measure true RMS values as follows (minimum):

a)	Current	:	per phase
2)	Voltage	:	V_{L-L} and V_{L-N}
3)	Power	:	kW, kVAR, kVA per phase and total at 3 phases
4)	Power Factor	:	per phase / average at 3 phases
5)	Frequency	:	incoming electrical source (Hz.)
6)	Energy	:	kWh, kVARh, kVAh (Class 0.5)
7)	Harmonic	:	THDi and harmonic order from 3rd up to 15th

3) The DPM shall be completed with built-in RS-485, Mod bus communication port or RS-422 communication ports (2 ports) to interface with Building Management System (BMS) and/or SCADA System.

4) The DPM shall be operated at rated voltage not exceed 600 VL-L and current rating ≤ 5 A (from secondary of current transformer).

5) The accuracy of power meter shall be as follows:

   1) Current / Voltage : 0.5 %

   2) Power / Energy : 0.5 %

   3) Power Factor : 0.5 %

(iii) Analog Meters

1) Each indicating instruments shall be semi-flush mounted, back connected, dustproof, fully tropicalized, switchboard type with a dull black case for mounting on a steel panel.

2) Except as otherwise specified, all indicating instruments shall be approximately 96 mm x 96 mm square with a 90°C scale arc. All meters shall be of the moving iron type. The maximum error of each indicating instrument shall not be more than 1% of full scale range.

3) The overload capacity is 1.25 times of the normal continuous load, except for motor circuit where the overload capacity of ammeter shall be 2.5 times the normal continuous load.

4) The ammeters for which the upper limited of the effective range does not exceed 20 amps may be direct (series) connected. For higher range, current transformer operated ammeter shall be used, and shall be designed for a secondary current of 5 amps.

5) Accuracy Class of the meters shall be 1.0 or better.

6) Voltmeters shall be the direct connection type with the accuracy class 1.0 (or better) and scale range: 0-500V.

(iv) Instrument Transformers

1) The current transformers shall be suitable for use with meters, and shall be tropical proof type with a 5A secondary and a primary rating equal to continuous current rating of circuit breaker. All current transformers shall have thermal and mechanical limits coordinated with the short-time rating of the circuit breakers with which they are used.

2) All current transformer secondary leads shall be brought out to shorting type terminal blocks located in the instrument compartments and shall be arranged to provide any combination of connections or polarity.

3) The current transformer shall not be used in dual-purpose role serving both instrument and protective device.

4) Accuracy Class of the current transformers shall be in accordance with the following function:

a)	Non-tariff metering	:	1.0
b)	Switchboard indicating instrument	:	1.0
c)	Protection	:	10P

5) The voltage transformer (if applied) shall be of the air-insulated type, with the windings encapsulated in epoxy resin or other suitable synthetic material. All voltage transformer secondary leads shall be brought out and connected, through secondary fuses, to terminal blocks for external connections or connection to other devices integral to the switchgear. These fuses and terminal blocks shall be mounted in the instrument compartments.

(v) Other Instruments and Accessories

1) On 3-phase, 4-wire systems, ammeter switches (if applied) shall have four operating positions, marked 'R', 'S', 'T' (or ‘A’, ‘B’, ‘C’), 'N', and 'OFF' position, and shall enable the single ammeter to read, in sequence, the currents in each of the three phases and the neutral wire. Ammeter switches shall have 'make-before-break' contacts.

2) On 3-phase, 4-wire systems, Voltmeter Switches (if applied) shall have seven operating positions, marked 'R-S', 'S-T', 'T-R', 'R-N', 'S-N', 'T-N', and 'OFF' position, and shall enable the single voltmeter to read, in sequence, each of the three line voltages and each of the three phase-to-neutral voltages. Voltmeter switches shall have 'break-before-make' contacts.

3) All indicating and pilot lamp assemblies shall be of the low power, cool operating, 24 V, switchboard type, with color caps and integrally mounted resistors. The color caps shall be Red, Yellow, and Blue. The lamp bulbs shall be replaceable from the front of the panels.

4) Undervoltage relay, if applied, shall be 3-phase, 4-wire, 415/240V, 50Hz unit. The undervoltage setting shall be adjustable to 10% with time delay setting 0-10s. The undervoltage relay shall include phase sequence and phase failure to trip the breaker when one phase falls symmetrically.

(h) Control Wiring and terminal blocks

(i) All control wires in the motor control center shall be flexible anneal stranded copper conductors with insulation for rated not less than 600V / 90^{o}C in compliance with IEC 60502.

(ii) The size of control wires shall be as follows:

1) 4 mm^2 for current circuit

2) 2.5 mm^2 for voltage circuit

3) 1.5 mm^2 for control circuit

(iii) The wiring shall be neatly and carefully installed in suitable wiring ducts with removable covers and shall be terminated at suitable terminal blocks. Splices shall not be permitted in control wiring or instrument leads. All hinged wiring shall be extra flexible.

(iv) Terminal block shall be spring type, screw-less, maintenance-free connection, and rail-mounted type. No current carrying metal shall be exposed after cables or terminal blocks accessories are connected.

(v) Wiring shall be identified at each end with a legible printed black marking sleeve. Sleeves shall be white tubing, sized to fit the insulation. Sleeves shall be able to rotate on the wire so not to inadvertently hide the wire number.

(3) Motors

(a) All motors shall comply with the latest ANSI or IEC standards or approved equivalent. They shall have ample margin on their rating for the required duty with due allowance for ambient temperature. All motor shall be induction type suitable for 50 Hz. Motors shall be of totally enclosed fan cooled squirrel cage screen-protect drip-proof type. High starting torque motors and low speed machines shall be started by reduced voltage starters.

(b) Motors shall normally be supplied by the manufacturer of the equipment driven by the motors.

(c) Control devices shall be provided for all motors. Single or double pole snap switches, specifically designed for alternating current operation only, may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating.

Automatic control devices such as thermostats may control the starting and stopping of motors directly, provided the devices used are designed for that purpose and have such a rating. Otherwise, magnetic starters shall be used, with the automatic control device actuating the control circuit.

(d) All motors shall be provided with a disconnection means. All 3-phase and single-phase motors above 1 kW (1 ½ HP) shall be provided with a safety-type disconnecting switch. For single phase motors below 1 kW (1 ½ HP), a general use snap switch, rated for alternating-current only shall be acceptable, provided the ampere rating or the switch is at least 125 percent of the full load current rating of the associated motor. Switches shall disconnect all ungrounded conductors.

(4) Low Voltage Cables

(a) General Requirement

(i) Power cables will be single, two, three or four conductors depending on the design in the detailed design stage which being used in a 3-phase - 4-wire - 50 Hz / TN-S system.

(ii) All cables shall be selected suitably for indoor and outdoor installations, wet and dry locations, exposed to sunlight, in conduit, in cable tray, in wireway as appropriate.

(iii) The conductors shall be unbroken for the full length of the reels.

(iv) Cables for life safety equipment shall be fire resistance cables (FR).

(b) PVC insulated cable (if applied)

(i) The cables shall be formed of individually annealed copper solid or stranded wire with heat resistant Polyvinyl chloride (PVC) insulation material which has rated not less than 750 V 70OC in compliance with TIS 11-2553 standard.

(ii) All cables size 6 mm2 or larger shall be stranded.

(c) XLPE Insulated Cable (if applied)

(i) Conductors shall be of soft or anneal uncoated stranded copper wire Class 2 in accordance with IEC 60228 and shall have a concentric lay.

(ii) Insulation shall be of cross linked polyethylene (XLPE) insulated and black Polyvinyl chloride (PVC) outer sheathed, which have rated not less than 0.6/1.0 kV 90^{O}C in compliance with IEC 60502 standard.

(iii) For multi-core conductor cable, the component of cable shall consist of Conductors (2 or 3 or 4 cores), Insulation (XLPE), Filler, Binding Tape, and Outer Sheath (PVC). Filler shall be of non-hygroscopic material.

(d) Fire Resistant Cable: FR Cable (if applied)

(i) Conductors shall be of soft or anneal uncoated stranded copper wire in accordance with IEC 60228.

(ii) Insulation shall be consisted of fire resistance tape (mica tape, etc.) cover the copper conductor and the outer shall be cross-linked polyethylene (XLPE) or polyolefin insulation which has thickness according to IEC 60502.

(iii) Outer sheath shall be of polyethylene or other material that have low smoke and zero halogen (LSF or LSOH or LSZH).

(iv) For multi-core conductor cable, the component of cable shall consist of Conductors (2 or 3 or 4 cores), Insulation, Filler, Binding Tape, and Outer Sheath. Filler shall be of low smoke/zero halogen material.

(v) Rated voltage of cable shall be 0.6/1.0 kV.

(vi) Cable shall not generate toxic gases in event burnt.

(vii) Standard for Testing of Fire Resistance shall be in compliance with BS 6387 Category C, W, Z or/and IEC 60331-1 / -2 / -11.

(viii) Standard for testing of flame retardant shall be in compliance with IEC 60332-1 / -3.

(ix) Standard for testing of smoke emission shall be in compliance with IEC 601034-2.

(x) Standard for testing of toxic gas emission shall be in compliance with IEC 60754-2.

(xi) Test reports shall be submitted for approval.

(xii) Cable fittings in each junction box shall be fire resistant type.

(e) Low Smoke/Zero Halogen Cable (LSF or LSOH or LSZH Cable) (if applied)

(i) Conductors shall be of soft or anneal uncoated stranded copper wire in accordance with IEC 60228.

(ii) Insulation shall be cross-linked polyethylene (XLPE) or polyolefin insulation which has thickness according to IEC 60502.

(iii) Outer sheath shall be of the low smoke/zero halogen material.

(iv) For multi-core conductor cable, the component of cable shall consist of Conductors (2 or 3 or 4 cores), Insulation, Filler, and Outer Sheath. Filler shall be of low smoke/zero halogen material.

(v) Rated voltage of cable shall be 0.6/1.0 kV.

(vi) Cable shall not generate toxic gases in event burnt.

(vi) Standard for testing of flame retardant shall be in compliance with IEC 60332-1 / -3.

(viii) Standard for testing of low smoke shall be in compliance with IEC 601034-2.

(ix) Standard for testing of toxic gas emission shall be in compliance with IEC 60754-2.

(x) Test reports shall be submitted for approval.

(f) Control Cable (CVV and CVVs) (if applied)

(i) All control cable shall be suitable for installation in wet and dry locations. The conductor shall be of soft or annealed strand uncoated copper wire.

(ii) The insulation shall be polyvinyl chloride (PVC) or polyethylene (PE) suitable for use on a copper conductor with a maximum operating temperature not less than 70°C.

(iii) Filler shall be used in the interstice of the multi-conductor cable where necessary to give the complete cable a substantially circular cross section. Fillers shall be Polyvinyl chloride (PVC) rod or Polyethylene (PE) materials.

(iv) The cable shall be helically wrapped over the filler and copper shielding with non-hygroscopic Mylar or Polyester tape.

(v) The shielding, for CVVs cables, shall be annealed copper tape or suitable width and shall be helically applied with a minimum 10% lap. The annealed copper tape shall be a least 0.1 mm thickness and substantially free from burrs.

(vi) The outer sheath shall be of black polyvinyl chloride (PVC) jacket over the wrapping and shall comply in all respects with ICEA S61-402 standards.

(vii) For life safety equipment; the control cables shall be fire resistant type complying with the standards as shown in item (d) “Fire Resistant Cable”.

(5) Raceway

All cables shall be laid in conduits, or in cable trays, or in wireways, or underground, or in cable trenches in accordance with the approved detailed design.

(a) Metal Conduits

(i) Rigid Steel Conduit (RSC), if applied, shall be steel and galvanized by the hot-dip process in compliance with NEMA ANSI C80.1 and complete with enamel finished inside the tube.

(ii) Intermediate Metal Conduit (IMC) shall be steel and galvanized by the hot-dip process in compliance with MENA ANSI C80.6 and complete with enamel finished inside the tube.

(iii) Electrical Metallic Tubing (EMT), if applied, shall be steel and galvanized by the hot-dip process in compliance with NEMA ANSI C80.3 and complete with enamel finished inside the tube.

(iv) Flexible Metal Conduit (FMC) shall be made from galvanized steel. The FMC installed in wet locations shall be of the liquid-tight type.

(v) Flexible conduit and fittings for life safety equipment shall be galvanized water-tight pattern, frame retardant; LSOH over-sheathed and separated earth wire enclosed within the conduit.

(vi) Conduit fittings and conduit bodies shall be galvanized steel in compliance with ANSI/NENA FB 1 standard.

(vii) The finished conduit and fittings shall have smooth surface for wire pulling, and shall not have any lumps of excess zinc and other injurious deflects to damage the wire.

(viii) The outside surface and threads on conduit shall have protective coating against corrosion. The threads on the fittings shall have paint, zinc or other protective coating against corrosion.

(ix) The standard manufactured Elbows shall be used for all sizes of conduits larger than 25 mm. (1 inch). The field bends to be handles with great care not to damage the conduits, will be permitted for conduit of 25 mm. (1 inch) and smaller.

(x) Conduit expansion joints shall be provided at building expansion joints. Metallic expansion fittings to ensure grounding continuity shall be applied.

(xi) Conduits and accessories installed in all **Stations** shall be capable of being subject to temperatures up to 500°C for 1 hour and shall not support combustion under the same temperature, in accordance with NFPA 130.

(xii) The following table shall be the comparison of nominal diameters of conduit in inches and in mm.

Conduit Diameter in Inches	½	¾	1	1 ¼	1 ½	2	2 ½	3	3 ½	4
Conduit Diameter in mm	15	20	25	32	40	50	65	80	90	100

(b) Non-metallic Conduit (if applied)

(i) Polyethylene Conduit shall be high density polyethylene (HDPE) type in compliance with ASTM D1248:

1) Class I: For embedding under road or street.

2) Class II: For embedding under pavement or footpath

(c) Cable Tray (if applied)

(i) Cable trays shall be of a perforated/corrugated pattern with lid, 2.0 mm minimum thickness mild steel with returned edges and hot-dip galvanized overall after fabrication in compliance with ASTM A123/A123M standard.

(ii) Cable trays and supports shall be capable of being subject to temperatures up to 500°C for 1 hour and shall not support combustion under the same temperature.

(iii) Fittings (such as tees, angle pieces, connectors) shall be of the same type of cable tray.

(iv) On site cutting of hot dipped galvanized components shall be properly repaired in the field using cold galvanizer.

(v) Support brackets and rods shall be of hot-dipped galvanized steel. Minimum mean coating thickness of the hot dipped galvanization shall be 65 micron. All bolts and nuts shall be electroplated with zinc with a minimum plating thickness of 25 micron.

(vi) Each section of the cable tray shall be electrically bonded, with a minimum 6 mm^2 cross section area earth-bonding strap or wire, to the next section to form an electrically continuous system and bonded to the main grounding system with green/yellow PVC insulated copper, single core cable. All edges, fittings, or any parts of the cable trays shall be finished free from bar, sharp edges, or projections damaging to the insulation or jacket of the cables.

(vii) 40% spare space capacity shall be provided for future cables laying inside the cable tray.

(d) Wireways (if applied)

(i) Wireways shall be made of hot-dip galvanized after fabrication to afford good corrosion resistance during storage, installation and service life. The minimum thickness required for wireways shall be as the following table (in millimeter unit):

Size of wireways (width x height)	Thickness
50 x 50 up to 100 x 50	1.2
100 x 100 up to 150 x 100	1.2
200 x 100 up to 300 x 100	1.6
150 x 150 up to 300 x 150	1.6
Larger than above	2.0

(ii) Wireways and supports shall be capable of being subject to temperatures up to 500^{O}C for 1 hour and shall not support combustion under the same temperature.

(iii) Fittings of wirewas shall be of the same type of cable tray.

(iv) On site cutting of hot-dipped galvanized components shall be properly repaired in the field using cold galvanizer.

(v) Support brackets and rods shall be of hot-dipped galvanized steel. Minimum mean coating thickness of the hot dipped galvanization shall be 65 micron. All bolts and nuts shall be electroplated with zinc with a minimum plating thickness of 25 micron.

(vi) Each section of the wireways shall be electrically bonded, with a minimum 6 mm2 cross section area earth-bonding strap or wire, to the next section to form an electrically continuous system and bonded to the main grounding system with green/yellow PVC insulated copper, single core cable. All edges, fittings, or any parts of the wireways shall be finished free from bar, sharp edges, or projections damaging to the insulation or jacket of the cables.

(vii) 40% spare space capacity shall be provided for future cables laying inside the wireways.

(6) Boxes and Accessories

(a) Outlet Boxes

(i) For wall/column recessed, the boxes shall be of steel sheet with not less than 1 mm thickness with hot-dip galvanized after fabrication, and completed with adjustable lug, ample knocked-holes and brass earth terminals fitted within the box.

(ii) For exposed works; the boxes shall be of die-cast aluminium, and completed with threaded hubs, neoprene gasket and earth terminal fitted within the box. The boxes shall be allowed for outdoor works in accordance with IP65 protection class.

(iii) The internal depth of a box shall be not less than 32 mm.

(iv) The corners of a box shall be mechanically and electrically continuous.

(b) Pull Boxes and Junction Boxes

(i) Pull boxes and junction boxes for branch circuits, indoor used, shall be as the same type of the outlet boxes and to be equipped with galvanized steel cover plate fastened with stainless steel screws.

(ii) Pull boxes and junction boxes for branch circuits, outdoor used, shall be of die-cast aluminium circular box completed with threaded hubs, earth terminal fitted within the box and fastening cover with neoprene gasket for IP65 protection class.

(iii) Pull boxes, which are used in feeder system (main feeders or feeders or sub-feeders), shall be made of steel sheet with not less than 1.6 mm thickness with hot-dip galvanized after fabrication, completed with ground flange, neoprene gasket and lid fastened with stainless steel screws. The boxes where used on outdoor location shall be IP65 protection class.

(iv) The corners of a box shall be mechanically and electrically continuous.

(v) Size of the pull boxes and junction boxes shall be selected in compliance with NFPA 70 and EIT 2001-56 standards.

(7) *Safety Switch*

(a) The safety switches shall be either Fused Safety Switches or Non-Fused Safety Switches as required on the approved detailed design.

(b) The switches shall be heavy duty type equipped with switch blades, a quick-make and quick-break operating handle and mechanism which shall be an integral part of the box. Service door of each safety switch shall be interlocked so that it cannot be opened while the switch is in "ON" position.

(c) Current rating of the switches shall be as approved at the detail design stage.

(d) All fuses for "fused safety switch" shall be of the high rupturing capacity (HRC) type of voltage rating up to 600 volts. Current rating shall be suitable for equipment loading.

(e) The switches shall be IP 31/NEMA 12 general purpose enclosure with knockouts unless otherwise noted or required. Switches (sealed) located outdoor or in wet areas shall have IP 54/NEMA 3 enclosures.

(8) Power Distribution Boards (if applied)

(a) General

(i) The distribution boards shall be of metal-enclosed indoor, factory-built type, and suitable for the 415/240 V – 3Ø – 4-Wire – 50 Hz system. A minimum protection of enclosure IP31 shall be provided. All distribution boards shall be provided with incoming and outgoing LED indication lights.

(ii) Before installing a distribution board, the Private Party shall check all the architectural drawings for possible conflicts of space, and adjust the location of the panel board to prevent such conflicts with other items.

(b) Panel Construction

(i) The distribution board enclosure shall be made of electro-galvanized steel sheet (minimum thickness 2 mm) and finished with epoxy-powder coating (minimum 60 micron) colored to the Engineer's representative's acceptance. The enclosure shall be completed with hinged doors and to be provided with standardized key lock and 3 sets of keys shall be provided for each distribution board. All DB doors shall be provided with separate latches in addition to the door locks.

(ii) The distribution panelboards shall be supplied fully equipped, wired, and proofed against vermin, dust and moisture, designed for free-standing or for wall-mounting, and cable access from beneath or above. Proper warning signs indicating danger and voltage level shall be provided.

(iii) Unless otherwise accepted, access to the boards shall be from the front, the doors shall be furnished with lift-off hinges to permit an opening enabling an unrestricted access to the board interior. All doors and covers shall be fitted with moulded gaskets of non-ageing material.

(iv) The distribution panelboards shall be provided with 3-phase tinned copper conductor busbars rated for continuous current and short circuit current. The busbars shall be designed to withstand dynamic forces due to peak short circuit current. All busbars including droppers and termination to the circuit breakers shall be color-coded conforming to the color coding as stipulated.

(v) Each distribution panelboard shall also be equipped with neutral busbar having the same rating as the phase-buses, and Earth busbar rating as 33% of the phase-buses.

(vi) As-built single line diagram, control circuit and layout plan shall be inserted in a permanent pocket on the inner side of the panel door of each distribution board.

(c) Circuit Breakers

(i) The circuit breakers installed in the distribution boards shall be moulded case circuit breakers (MCCB) complying with IEC 60947-1 and IEC 60947-2 standard.

(ii) Other requirement for them shall refer to clause 2.16.2.2 (2) (e) "Moulded Case Circuit Breaker"

(d) Measuring Devices and Instruments

(i) Multifunctional digital power meters, if applied, shall refer to the specification as described in Clause 2.16.2.2 (2) (g) (ii).

(ii) Analog Meters, if applied, shall refer to the specification as described in Clause 2.16.2.2 (2) (g) (iii).

(iii) Instrument Transformers, if applied, shall refer to the specification as described in Clause 2.16.2.2 (2) (g) (iv).

(iv) Other instruments and accessories shall refer to the specification as described in Clause 2.16.2.2 (2) (g) (v) for one or more items are applied in the design.

(e) Internal cabling

(i) All internal cabling in each item of equipment shall be installed in cabling channels or conduits. Exposed cabling shall be kept to a minimum but where necessary, the wires shall be formed into compact groups suitably bound together and properly supported.

(ii) All conductors shall be terminated with suitable pressure type terminal lugs of proper sizes for terminal studs at the terminal blocks or shall be terminated in a manner compatible to the terminals of the instruments.

(iii) All conductors shall run continuously between terminal studs without splices or taps and all conductors shall be labeled at each termination with wire number as designated on the circuit diagrams.

(iv) All internal cabling shall be insulated anneal stranded copper wire, rated at not less than 600V / 90^{o}C. And minimum cross-sectional area shall be;

1) 1.5 mm^2 for control circuits

2) 2.5 mm^2 for voltage and current circuits

2.16.3 Execution

2.16.3.1 Installation

(1) The Private Party shall install the Electrical and Control Works in accordance with the approved Working Drawings and manufacturer's instructions, and in compliance with the requirement of NFPA 70; EIT 2001-56; and the recommendation of MEA.

(2) The floor-standing type of the Motor Control Centers and Power Distribution Boards (if applied) shall be installed on the concrete base 150 mm. heights.

(3) The wall-mounting type of the Motor Control Centers and Power Distribution Boards (if applied), generally, shall be mounted rigidly with expansion bolts on concrete or nuts and bolts on wooden or metal wall at a height of 1,800 mm. above the finished floor to top of the panels.

(4) All metal and non-carrying current parts shall be grounded.

(5) Low Voltage Cables

(a) In general, the Power cables shall be run in conduits, in cable tray and shall be run concealed in ceiling, floor, and wall or as indicated on the approved Working Drawings.

(b) No wire shall be pulled into the conduit system until it is complete in all details.

(c) Lubricant shall be used to facilitate wire pulling. Lubricants shall be approved for using with the insulation specified.

(d) Splicing of wires and cables shall be allowed only in the luminaires, receptacles and proper junction box with an approved method of insulation. No splice shall be made in conductors for instrument circuits or control circuits.

(e) Splicing of large wires and cables shall be by compression type, solderless wire connectors indented by special hydraulic tool. The splice shall be insulated with plastic insulation tape such as Scotch Brand No.35. Thickness of the tape shall not be less than three layers or at least the same thickness as the wire insulation.

(f) Compression type, solderless lugs indented by proper tool shall be used at the end of all wires and cables and shall be connected to the screw type terminals of the equipment and to the bus bars.

(g) The cut end of cables shall be treated to prevent seepage of water into the cable.

(h) The Private Party shall provide all necessary materials for installation of the cables, such as grounding lead wires, compression type terminals, metal fitting, bolts and nuts including cable identification and felt packing to be inserted between cable and cleats.

(i) The unoccupied space in cable knockouts and conduits after cable insertion shall be filled, with duct seal to prevent insects and small animals from entering the equipment housing.

(j) Where cables are buried in the ground the minimum depth of burial shall be 0.6 m. Cables shall be laid on 0.15 m and covered by a 7.5 cm. layer of clean sand. Cables shall be covered with tiles and or marking tape and the trenches backfilled to grade level.

(k) Cables under roads shall be enclosed in ducts supplied and installed by the electrical work.

(l) All cables shall be identified by means of cable tags fitted to each termination point and at 30 meter intervals along cable route.

(m) Cable route markers shall be installed above ground along underground cable routes. These shall be located at 30 meter inter- intervals, at changes of direction and at entries to buildings.

(n) The Private Party shall be responsible for the supervision of the cable trench excavation, sanding and backfilling, supply and installation to warning tape, cable tiles and cable marker posts as detailed on the approved Working Drawings and in these Specifications.

(o) Cables shall be laid in one continuous length.

(p) Conductors with compression type terminals and insulation cover shall be arranged in a neat manner on terminal box or equivalent terminals. The Private Party shall install plastic cable tie-wraps as required to neatly group cables and to keep the weight of the cable from damaging terminations.

(q) The conductors in vertical raceways shall be supported if the vertical rise exceeds the values in following table:

Spacing for Conductor Supports in Vertical Raceway		
Size of Cable (mm^2)	**Maximum Spacing (m)**	**Remark**
50 or smaller	30	If the vertical run is less than 25% of max. Spacing in table, cable supports will not be required.
70 thru 120	24	
150 thru 185	18	
240	15	
300	12	
over 300	10	

(6) Conduits & Accessories

(a) All conduits shall be as specified herein with a minimum size of 15 mm. unless otherwise noted.

(b) Where the conduits enter the cabinets and equipment, conduit bushings and double locknuts shall be used.

(c) The end of all conduits shall be tightly plugged to exclude dust and moisture while the buildings are under construction.

(d) The bending radius of the conduit shall not be less than six times the outer diameter of the conduits. The total bending angles of conduits shall not exceed 360 degrees in any one run.

(e) The conduits used shall not have any internal and external defects. Each end of the conduit shall be made smooth with the conduit reamer to prevent damage to the wire.

(f) A short piece of flexible metal conduit shall be used for connecting all motors, vibrating equipment, recess lighting fixtures and junction boxes and as otherwise specified.

(g) The wiring system shall consist of PVC insulated cables drawn into conduit. Wiring shall be loop-in style without joints.

(h) The wiring capacity of conduits shall conform to the requirement in EIT Standard 2001-56 and/or the current edition of NFPA 70.

(i) Conduit shall be run neatly on the surface or buried within the carcase of the buildings as indicated on the approved Working Drawings and in these Specifications. Conduit shall be run at least 0.15 m. clear of plumbing and mechanical services.

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

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

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

(m) Provide suitable fittings to accommodate expansion and deflection where conduit crosses seismic, control and expansion joints.

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

(7) Cable Trays

(a) The supports for horizontally run-cable tray shall be provided such that they shall be capable to adjust vertically. Where tray and ladder systems are supported by drop rods additional restraints shall be included to provide adequate lateral support. Restraints shall be installed at all bends and intersections and at intervals not exceeding 1.5 meters on straight runs. Support rods shall be at least 6 mm diameter. Trapeze or other hangers shall be clamped on the drop rods between two nuts.

(b) Cable tray or ladder shall not be installed across building or structural expansion joints. On horizontal runs the tray or ladder shall be installed with a 20 mm gap at the expansion joint. Supports shall be installed within 150 mm on either side of the joint.

(c) Provide all openings on floors and walls necessary for cable trays unless indicated as being provided by others.

(8) Wireways

(a) All length of the wireways shall be supported by the metal hangers at every interval not more than 1.50 m for horizontal and vertical installation. The supports for horizontal run shall be provided such that shall be able to adjust vertically for neat alignment.

(b) Provide all openings on floors and walls necessary for wireways unless indicated as being provided by others.

(9) The Conduits, cable trays, wireways and termination boxes for Electrical system shall have to be painted strip color coding at interval 1 m along total length of raceways with;

(a) Normal Power : Orange

(b) Essential Power : Yellow

(c) Control system : Blue

2.16.3.2 Testing and Commissioning

(1) Motor Control Centers / Power Distribution Boards

(a) All motor control centers / power distribution boards shall be not only tested at the manufactory but also checked at the site for the following performances.

(i) Insulation of all cables

(ii) Operating and protecting of the equipment

(iii) Grounding

(2) Low Voltage Cables

(a) All cables fed to the equipment shall be meggered phase-to-phase and phase-to-ground before the equipment is connected and phase-to-ground after the equipment is connected and all connection are tapped.

(b) Insulation resistance tests shall be performed by using a 500 Vdc megger on the 400 volts system. Insulation resistance shall be not less than one mega ohms per 1000 volts rating.

2.17 FIRE BARRIER WORK

2.17.1 General

2.17.1.1 General Requirement

(1) After erection of materials and equipment through wall and opening had been completed, it is the responsibility of the Private Party to fill up voids and openings with fire resistant materials which conform to NEC article 300-21 and ASTM to protect fire or smoke from spreading out from one room to another room through these voids and openings.

2.17.1.2 Standards and References

(1) The fire barrier shall comply with the following codes and standards.

(a) Fire Protection Association (NFPA)

(b) Underwriters Laboratories, Inc. (UL)

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

2.17.1.3 Submittals

(1) The Private Party shall submit material selector, catalog, material lists, technical data and method of installation request for approval.

2.17.1.4 Warranty

(1) All material and installation or barrier work shall be guaranteed by the Private Party for at least 2 years.

2.17.2 Material

2.17.2.1 Description

(1) The applied to wall considered to be a fire or acoustical protection wall, unless otherwise specified. Cover or escutcheon plates shall be provided, wherever exposed, and shall be neatly placed to the satisfaction of the SRT.

(2) Also, after the erection of all pipe, ducts conduits, wiring, and raceways in the shaft, block-out or any floor openings, the voids must be sealed with 2-hour fire rating material, as approved by the SRT unless specified otherwise.

2.17.2.2 Component

(1) The fire barrier materials shall have properties as the following

a) The fire barrier materials shall be based on the standards of Underwriter's Laboratory Inc.

b) The fire barrier materials shall be of minimum 2-hours fire resistant rating.

c) The fire barrier materials must not be toxic during installation or incase of fire.

d) Easy to be dismantled and replaced in case of rearrangement.

e) Withstand over vibration.

f) Easy installation.

g) Before and after fire spreads, the fire barrier materials must be strong enough.

h) The fire barrier materials must be submitted to the SRT for approval before installation.

2.17.3 Execution

2.17.3.1 Installation

(1) At every voids and openings, fire barrier materials shall be installed where:

(a) Every voids, sleeves, and openings appear on wall, floor, beam and shaft, provided for raceway installation, must be sealed after the erection work had been completed.

(b) Voids, sleeves, and openings which are provided for future installation.

(c) Voids between electrical conduits and sleeves.

(d) Voids between electrical cabling and raceway on fire wall and floor.

(e) Voids between raceway and sleeves on fire wall and floor.

(2) The method of fire barrier material installations must be submitted to the SRT for approval before installation.

2.17.3.2 Testing and commissioning

(1) Operating test run shall be provided from manufacturer.

2.18 PAINTING AND COLOR CODES

2.18.1 General

(1) The following clauses specify the material or paint system, preparation and application requirements for painting of all equipment, housing, vessels, containers, pipelines, pipe supports, and other structural steelworks which are not protected by galvanizing or an approved protective coating.

(2) During the progress of the painting work, the Private Party shall avoid spotting of the floors, walls, and other adjacent equipment. All spotting, if any, shall be cleaned immediately. Any damages, which may result from painting shall be under the Private Party's responsibility.

(3) When surface cleaning, blasting and painting is done in the Private Party's factory, such preparation and painting shall be done with the prior consent of the Engineer’s Representative. If necessary, the Private Party shall arrange for presentation the Engineer’s Representative for inspection at his factory.

(4) All painting shall be completed before applying of pipe insulation and commissioning.

(5) Prior to equipment installation all metal surfaces shall be treated with anti-corrosive materials and/or painted according to these Specifications.

(6) The preparation and application of the painting materials shall adhere strictly to the manufacturer's recommendations.

(7) The equipment or materials that have previously been treated with anticorrosive materials and painted from the factory must be inspected for their workmanship. Any defects, such as scratches, peels and rust shall be repaired and repainted to the approval of the Engineer's Representative.

2.18.2 Material Not used.

2.18.3 Execution

2.18.3.1 Surface Preparation and Cleaning

(1) Metal or ferrous Metal Surfaces

(a) Rust at welding joints and other defects shall be removed by scraping. Wire brushes or sandpaper shall be used to clean the surfaces and to remove rust. Sand-blasting may be used to remove loose rust and other foreign substances. Mordant solution such as thinner, gas, turpentine shall be used to remove grease, oil or organic coating. Then the surfaces shall be cleaned whitewater and thoroughly dried or blow-dried.

(b) The application of prime coats, which follows shall adhere strictly to the manufacturer's recommendations.

(c) Old paint coats shall be removed by scraping before application of new paint.

(2) Non-Ferrous Metal Surface

Non-ferrous metal surface shall be cleaned with sandpaper and turpentine before prime coating. Wire-brushing or sand-blasting shall not to be used.

(3) Zinc and Zinc-Annealed Surfaces

Before prime coating, grease and dirt shall be removed with proper solution.

(4) Copper, Lead, Plastic and Brass Surfaces

Before the application of prime coats, the surface shall be cleaned with sand paper, then proper solution shall be used to remove dust.

2.18.3.2 Brush or Spray Painting

(1) Each paint coat shall be left until completely dry before subsequent applications.

(2) Painting can be classified into 2 coats :-

(a) Prime coat for rust prevention and/or adhesion of the finishing coats.

(b) Finishing coat for final appearance or for symbolizing the system codes. Types of paint used shall depend on the material as well as on the environment.

2.18.3.3 Paint System

(1) For Equipment

(a) All of the manufacturer's applied coating or painting surfaces of all equipment such as pump, valve, and other accessories or fittings, etc., which have been damaged, or have been applied with inappropriate paint system for the services and environment of the equipment, shall be corrected or removed and repainted.

(b) The above requirements shall also be applied to all damaged galvanized surfaces of the equipment and materials.

(c) Paint system for equipment, valves, etc. shall be of the same grade of paint system specified for pipe work that those equipment, valves, etc. are connected, except that the surface cleaning may be mechanical wire brushing.

(2) For Vessel

Products vessel which are constructed of stainless steel material shall have their surface polished internally and externally as specified under other section. No painting is required on uninsulated stainless steel and galvanized steel surface. However, for vessel externals of carbon steel components shall have their surfaces treated and coated as specified below for the carbon steel vessels.

(a) Uninsulated Vessel of Black Steel

(i) Exterior

Surface Preparation	-	Abrasive blasted to a Near white grade SSPC-SP-10 (Sa 2 1/2)
Prime Coat	-	Zinc Ethyl Silicate Coating 3 mils (75 micron) DFT
Second Coat DFT	-	High build epoxy 5 mils (125 micron)
Finish Coat	-	Polyurethane 2 mils (50 micron) DFT

(ii) Interior

Surface Preparation	-	Same as exterior
Prime Coat	-	High build epoxy 5 mils (125 micron) DFT
Second Coat	-	High build epoxy 5 mils (125 micron) DFT

(b) Insulated Vessel of Galvanized Steel

(i) Exterior

Surface Preparation	-	Solvent cleaning and degreasing
Primer Coat	-	PVB Zinc chromate self etching primer or wash primer 0.4 mils (10 microns) DFT
Second Coat	-	Chlorinated rubber based primer 3.4 mils (2x40 microns) DFT

(ii) Interior

Not required

(3) For Piping and Material Other Than Equipment Vessel

Type of Surface	Normal Area	Humid/Corrosive Area
(a) Black steel pipe, Black steel sheet, Switchboard, Panel	1st coat: Read lead primer. 2nd coat: Read lead primer. 3rd coat: Alkyd finishing paint. 4th coat: Alkyd finishing paint.	1st coat: Epoxy read lead primer. 2nd coat: Epoxy read lead primer. 3rd coat: Epoxy finishing paint. 4th coat: Epoxy finishing paint.
(b) Galvanized steel pipe, Galvanized steel sheet duct work exposed to view. If color coding is not specified, bronze color shall be used for finishing coat	1st coat: Wash primer. 2nd coat: Zinc chromate primer. 3rd coat: Alkyd finishing paint. 4th coat: Alkyd finishing paint.	1st coat: Wash primer. 2nd coat: Epoxy read lead primer. 3rd coat: Epoxy finishing paint. 4th coat: Epoxy finishing paint.
(c) PVC pipe, Plastic pipe	1st coat: Wash primer. 2nd coat: chlorinate rubber finishing paint. 3rd coat: chlorinate rubber finishing paint.	1st coat: Wash primer. 2nd coat: chlorinate rubber finishing paint. 3rd coat: chlorinate rubber finishing paint.
(d) Cast-iron pipe inclusive of underground pipe	1st coat: Coal tar Epoxy. 2nd coat: Coal tar Epoxy.	1st coat: Coal tar Epoxy. 2nd coat: Coal tar Epoxy.
(e) Copper tube, Stainless steel sheet, Aluminium steel sheet, Light alloy, Lead	1st coat: Wash primer. 2nd coat: Alkyd finishing paint. 3rd coat: Alkyd finishing paint.	1st coat: Wash primer. 2nd coat: Alkyd finishing paint. 3rd coat: Alkyd finishing paint.
(f) Closed cell foam plastic. Use color tape strips to indicate color codes.	-	-
(g) Outdoor kitchen exhaust duct	1st coat: As recommend by manufacturer. 2nd coat: As recommend by manufacturer.	

Type of Surface	Normal Area	Humid/Corrosive Area
	3rd coat: Heat resistant 100°C alkyd finishing paint	

Note: In case where there is a paint repair resulting from welding, cutting, drilling, polishing, or threading, zinc rich primer shall be used prior to the application of finishing paint.

2.18.3.4 Color Codes

(1) All pipes shall be color-coded.

(2) In the electrical system, color coding shall be only at the conduit clamps and the cover of junction boxes.

(3) Strip sizes of color codes (for insulated pipes) and the letter size are as follows:-

Pipe Size		Width of Color Strip	Letter Size
(mm.)	(inch.)	(mm.)	(mm.)
20 - 32	(3/4”-1.1/4”)	200	12
40 - 50	(1.1/2”-2”)	200	20
65 - 150	(2.1/2”-6”)	300	30
200 – 250	(8”-10”)	300	65
300 and larger	(12”)	500	100

(4) Location of Color codes, symbols and arrows indicating directions are as follows:-

(a) Every 6-meter (20 ft.) internal of straight line pipe.

(b) Near all valves.

(c) Every change of direction and/or separation.

(d) Where pipes passing through walls or floors.

(e) Near service pipe.

2.18.3.5 Color Codes of Various Systems

(1) The identifications previously mentioned shall have colours as follows :-

		Letters	Colour Code	Colour Symbol
(a)	Chilled water supply	CHS	Green	White
(b)	Chilled water return	CHR	Green	White
(c)	Chilled water reverse return	CHRR	Green	White
(d)	Condenser water supply	CDS	Orange	White
(e)	Condenser water return	CDR	Orange	White
(f)	Conduit for electrical		Blue	-

(2) The SRT will make final selection of colors. All uninsulated pipes shall be painted all over the pipe surface.

2.19 STANDARD FIELD TESTS

2.19.1 General

(1) All water pipes shall be cleaning & flushing with clear water before testing.

(2) All air ducts shall be cleaning inside before testing.

(3) Tests shall be performed in the presence of the Engineer's Representative. The Private Party shall give timely notice and furnish the Engineer's Representative the required certificates of testing for review.

(4) Work which fails to meet the requirements of any test or does not meet the requirements of the contract documents shall be considered defective and shall be promptly corrected or removed from the site.

(5) Test instruments shall be tested for accuracy by an approved laboratory or by the manufacturer. Instruments and appliances required for tests shall be furnished by the Private Party. If gauges, thermometers, etc. which are to be left permanently installed are used for the tests, they shall not be installed until just prior to the tests to avoid possible changes in calibration.

(6) The Private Party shall submit the star-up and test report form to the Engineer's Representative for approval before starting-up and testing each system.

2.19.2 Material Not used.

2.19.3 Execution

2.19.3.1 Testing for Equipment

After installations are completed, all equipment shall be test run. Any adjustments that are needed shall be made to assure that all equipment will operate either the required performance. Report forms to contain following minimum data listings shall include design and actual conditions for each Item mentioned below:

(1) Water Chillers

(s) Date and time of test.

(t) Chiller make, type, name and serial number.

(u) Number of pumps running.

(v) Flow rates for chilled water.

(w) Temperatures of chilled water at inlet and exit of pumps, chillers, etc.

(x) Pressures of chilled water at inlet and exit of pumps, chillers, etc.

(y) Flow rates for condenser water.

(z) Temperatures, as above.

(aa) Pressures, as above.

(bb) Compressor motor data.

(cc) Compressor rpm.

(dd) Suction and hot gas temperatures.

(ee) Suction and hot gas pressure.

(ff) High pressure cutout.

(gg) Condensing temperature.

(hh) Evaporator temperature, pressure drop.

(ii) Flow switch function.

(jj) Chiller automatic control sequencing, including the interlocking of all the chillers.

(2) Cooling Towers

(a) Date and time of test.

(b) Ambient conditions at time of test.

(c) Cooling tower make, type, name and serial number.

(d) Number of pumps running.

(e) Flow rates for condenser cooling water.

(f) Temperatures of condenser water at inlet and exit of pumps, cooling towers, etc.

(g) Pressures of condenser water at inlet and exit of pumps, cooling towers etc.

(h) Number of fans working in cooling towers.

(i) Amount of bleed water added during the test period.

(j) Automatic bleed-off control sequencing.

(k) Make-up water control sequencing.

(3) Pumps

(a) Date and time of test.

(b) Ambient conditions at time of test.

(c) Pump make, type, name and serial number.

(d) Pump rpm.

(e) Pump amperage (Individual Operation).

(f) Pump amperage (Multiple Operation).

(g) Rated motor amperage, starter relay number and amperage rating.

(h) Pump inlet pressure (Individual Operation).

(i) Pump inlet pressure (Multiple Operation).

(j) Pump outlet pressure (Individual Operation).

(k) Pump outlet pressure (Multiple Operation).

(l) Chilled water flow rate GPM (Multiple Operation).

(m) Condenser cooling water flow rate GPM (Multiple Operation).

(n) Water temperatures.

(o) Water flow rate GPM.

(4) Air Handling Units and Fan Coil Units

(a) Date and time of test.

(b) Air handling unit and fan coil unit make, type, name and serial number.

(c) Fan rpm.

(d) Pressure drop across filter

(e) Fan discharge static pressure

(f) Fan motor amperage

(g) Rated motor amperage, starter number and ampere rating.

(h) Recirculated air CFM

(i) Outside air CFM

(j) Outside conditions (DB and WB)

(k) Return air conditions (DB and WB)

(l) Entering coil conditions(mixing) (DB and WB)

(m) Leaving coil conditions (DB and WB)

During test run, the air filters of testing sets shall be used.

(5) Exhaust Fans

(a) Date and time of test

(b) Fan make, type, name and serial number.

(c) Fan rpm

(d) Fan discharge static pressure

(e) Fan motor amperage

(f) Rated motor amperage, starter number and ampere rating

(g) Exhaust air CFM

(6) Air Handling Units and Fan Coil Units

(a) Date and time of test.

(b) Air handling unit and fan coil unit make, type, name and serial number.

(c) Fan rpm.

(d) Pressure drop across filter

(e) Fan discharge static pressure

(f) Fan motor amperage

(g) Rated motor amperage, starter number and ampere rating.

(h) Re-circulated air CFM

(i) Outside air CFM

(j) Outside air conditions (DB and WB)

(k) Return air conditions (DB and WB)

(l) Entering coil conditions (DB and WB)

(m) Leaving coil conditions (DB and WB)

During test run, the air filters of testing sets shall be used.

(7) Exhaust Fans

(a) Date and time of test

(b) Fan make, type, name and serial number.

(c) Fan rpm

(d) Fan discharge static pressure

(e) Fan motor amperage

(f) Rated motor amperage, starter number and ampere rating

(g) Re-circulated air CFM

2.19.3.2 Testing for Pipe Works

(1) Water piping shall be tested with water pressure of not less than specified or 1 ½ times the maximum working pressure, whichever is greater, at the lowest point in the system. Care shall be taken to avoid putting excessive pressure on safety devices, etc. These delicate control mechanisms shall be removed during the tests to prevent shock damage. The system shall be tested when water temperatures and average ambient temperatures are approximately equal and constant. Test pressure shall be maintained for not less than 30 minutes without an appreciable drop after the force pump has been disconnected.

(2) Piping may be tested a section at time in order to facilitate the construction.

(3) Leaks in screwed fittings shall be corrected by remaking the joints. Leaks in welded joints shall be cut out and rewelded. Caulking of leaks will not be permitted.

(4) After pressure tests have been made, the entire water-distribution system to be sterilized shall be thoroughly flushed with water until all entrained dirt and mud have been removed before introducing chlorinating material. The chlorinating material shall be either liquid chlorine or hypochlorite. The chlorinating material shall provide a dosage of not less than 50 PPM. and shall be introduced into the system in an approved manner. The treated water shall be retained in the pipe long enough to destroy all nonspore-forming bacteria. Except where a shorter period is approved, the retention time shall be at least 24 hours and shall produce not less than 10 PPM of chlorine at the extreme end of the system of the retention period. All valves in the system being sterilized shall be opened and closed several times during the contact period.

(5) The system shall then be flushed with clean water until the residual chlorine is reduced to less than 0.2 PPM. During the flushing period all valves and faucets shall be turned on and off several times.

2.19.3.3 Testing for Duct Work

(1) High pressure blower with control damper shall be used for test apparatus. Air for testing shall be introduced into the system through a suitable filter and dryer to exclude all impurities.

(2) A flow measuring device shall be of an orifice assembly consisting of straightening vanes and an orifice plate mounted in a straight tube with properly located pressure taps. Each orifice assembly is accurately calibrated with its own calibration curve, which shall also be submitted to the Engineer's Representative for approval. Pressure and flow readings shall be taken with U-tube manometers.

(3) Test procedures shall be of audible test with a pressure of 50 mm WG in excess of designed duct operating pressure. All joints for audible leaks shall be surveyed and each leak shall be marked and repaired after shutting down the blower. After all audible leaks have been sealed, the orifice section with a pressure of 25% in excess of designed duct operating pressure.

(4) Total allowable leakage shall conform to the first edition of "HVAC Air Duct, Leakage Test Manual" of SMACNA standard. When partial sections of the duct system are tested, the summation of the leakage for all sections shall not exceed the total allowable leakage.

2.19.3.4 Testing for Electrical Works

(1) The electrical installation shall be functionally tested and checked to insure that all equipment, devices and wiring have been properly installed and will operate as intended.

(2) The conduit system shall be checked to ensure that it has been installed for safe and reliable operation. Special attention shall be given to ensure NEC or approved equivalent requirements are satisfied in weatherproof enclosures, sealed location and sealed pouring. Conduit supports, fittings covers, etc. shall be checked.

(3) Insulation resistance tests shall be performed using a 500-volt DC megger on the 400-volt system. Insulation resistance shall not be less than one mega-ohm per 1,000-volt rating.

(4) All electrical tests of equipment shall be recorded. A copy of the record shall be furnished to the Engineer’s Representative.

(5) Power cables, 600-volt rated shall be meggered phase-to-phase and phase-to-ground before the equipment is connected and phase-to-ground after the equipment is connected. All connections are taped with color code tape.

(6) All motor control centers equipment shall be visually inspected, and where possible, test-operated to ensure that all components have been furnished and installed and will operate in accordance with the manufacturer's recommendations.

(7) The tests shall be for fuses, meters, current transformers, potential transformer, overload relays, wiring, connections for power, control, grounding, etc.

(8) The motor control center buses shall be meggered phase-to-phase and phase-to-ground.

(9) Each starter and contactor shall be test-operated.

(10) The actual running current of the motor shall be checked against the nameplate current to insure that the motor is not overloaded.

(11) Each adjustable circuit breaker shall be set in accordance with manufacturer's recommendations. Each motor shall be meggered phase-to-ground.

(12) Each motor shall be checked for proper lubrication, shaft alignment, electrical connections, ground connection, control circuit operation, space heater, drain operation, etc. Each motor shall be “bumped” to verify proper rotation.

(13) Ground resistance shall be checked, using Megger Ground Resistance Test Instrument. The maximum resistance to grounding shall be 2 ohms.

2.19.3.5 Testing for Automatic Control System

(1) The Private Party shall require the control supplier to supervise and commission the control system. The testing for the automatic control system include the following service :-

(a) Prior to commencement of work on site:-

Advise on the operation of the control system, identification and correct positioning of control equipment and wiring connections.

(b) During the progress of the site work:-

Advise on the correct location and installation of controls and correct wiring on controls. Particular attention shall be paid to the mounting of actuators on valves, dampers, and the correct linkages form actuators to valves and dampers. The work shall be carried out on the basis of regular visits throughout the period of Phase I.

(c) When the installation is completed :-

Commission the complete control system supplied under this section of these Specifications to provide detailed operation and performance figures.

(2) Provide all normal servicing and maintenance during Phase II – Operation and Maintenance for all equipment provided under this PPP Contract. In addition the following tests shall be carried out:-

(a) Insulation resistance

(b) Earthing continuity

(c) Polarity

(d) Continuity

(e) Phase proving tests to ensure that phases are connected in the specified manner and correct sequence throughout.

(f) Earth fault loop inspection test.

(3) Final commissioning of control systems after the Engineer's Representative's approval of the test records the systems shall be finally commissioned.

2.20 VARIABLE REFRIGERANT FLOW AIR CONDITIONER

2.20.1 General

2.20.1.1 General Requirement

(1) The Private Party shall furnish and install variable refrigerant flow (VRF) air conditioner as shown on the Drawings and/or specified herein.

(2) The VRF air conditioner shall be specially designed for 50 Hz. Electrical systems and the cooling capacity shall not be less than that indicated on the Drawings.

2.20.1.2 Standards and References

2.20.1.2.1 The VRF air conditioner shall comply with the following codes and standards.

(1) ANSI/ASHRAE 128 : Method of Rating Unitary Spot Air Conditioners (ANSI Approved)

(2) ANSI/AHRI 210/240 : Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment

(3) AMCA 301 : Method for Calculating Fan Sound Ratings from Laboratory Test Data

(4) TIS 2134 : Room Air Conditioners : Energy Efficiency

(5) TIS 2564 : Room Air Conditioner : Installation

(6) EIT 3008 : Standard for Air-Conditioning and Ventilating System

2.20.1.2.2 In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

2.20.1.2.3 All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

2.20.1.2.4 The standards and codes as mention in 1.2.1 can be equivalent by another standards and codes, if it equal or better than standards and codes mention in 1.2.1 when comply between two codes.

2.20.1.3 Submittal

The Private Party shall submit VRF air conditioner's performance selection, matching curve, material lists and technical data and all necessary information for approval before purchasing.

2.20.1.4 Quality Assurance

2.20.1.4.1 All part of the VRF air conditioner shall be guaranteed by the manufacturer and/or by the Private Party for at least two year after handover.

2.20.1.4.2 All compressors shall be guaranteed by the manufacturer for atleast 3 year.

2.20.1.4.3 The equipment manufacturer plant shall be ISO 9000 certified

2.20.1.4.4 Both the fan coil units and condensing unit shall be factory assembled and tested at the factory.

2.20.2 Material

2.20.2.1 Description

2.20.2.1.1 The unit shall be assembled and matching parts from factory as standard model. The unit consisting of outdoor Condensing Unit and indoor Air handler are connected with refrigerant pipe and electrical wires, part of each section will be described below:

2.20.2.1.2 Evaporator unit, condensing unit, refrigerant pipe, filter drier, sight glass, shall be installed in the position indicated on the drawings or advised by the manufacturer.

2.20.2.1.3 The air conditioning equipment shall be air cooled, inverter driven, split type multi-system air conditioner consisting of indoor units and outdoor units. The VRFsystem suitable for HFC-407c, HFC-410a or any zero ODPrefrigerant, factory tested, evacuated dehydrated and pressurized with refrigerant holding charge for field installation. The unit shall be in accordance with the following Specifications as stated below.

2.20.2.2 Component

2.20.2.2.1 Condensing Unit

(1) The condensing unit shall be air cooled, weatherproof type for outdoor installation.

(2) Casing shall be made of steel sheet, bonded and finished with baked enamel. The casing may be made of aluminum or fiberglass with equivalent strength.

(3) The condensing unit shall enable the operation to be optimized for either energy efficiency or rapid cooling.

(4) The refrigerant piping length shall be extended up to 150m and total piping length up to 500m with 90m level difference without any oil traps.

(5) The condensing unit shall incorporate an automatic test operation button to perform an automatic system check. This includes control wirings, shutoff valves, sensors and refrigerant volume. The results shall return automatically after the check finishes.

(6) Operating data for the preceding 3 minutes is automatically stored in memory. Should a malfunction occur, this speeds up the process of identifying and fixing the cause of the problem. It shall also help in developing measures to eliminate malfunctions.

(7) The outdoor unit shall have two scroll compressors and be able to operate even in case that one of the compressor is out of order.

(8) The compressor shall be of highly efficient hermetic scroll type and equipped with inverter control capable of changing the speed in accordance to the cooling load requirement.

(9) The Inverter driven compressor in each condensing unit shall be of highly efficient reluctance DC, hermetically sealed scroll type. Neodymium magnets shall be adopted in the rotor construction to yield a higher torque and efficiency in the compressor instead of the normal ferrite magnet type.

(10) The outdoor unit shall have multi-step of capacity control to meet load fluctuation and indoor unit individual control.

(11) In the case of a system comprising of plural condensing units, it is required that the condenser unit with the lowest inverter compressor running time be the first to operate at each start up. This duty cycling feature will be factory supplied and fitted.

(12) Electricity characteristic shall be 230/1/50 or 400/3/50 as indicated on the Drawings.

(13) Condenser coil shall be seamless copper tubes with mechanically expanded into aluminum fins, leak tested and pressure tested at 3,100 kPa (450 psig).

(14) The aluminum fins shall be covered by anti-corrosion resin film. The coils shall be complete with corrosion treatment. The thickness of the coating must be between 2.0 to 3.0 microns.

(15) The condensing unit fan motors shall have multiple speed operation of the DC inverter type, and be of high static resistance.

(16) The Condensing Unit shall be capable to operate at further reduced noise during night time. Such mode of operation shall either by automatic or manual setting.

(17) The condenser fan shall be automatically regulated with steps capacity reduction according to the condensing pressure detected on the condenser side. This would provide better part load efficiency.

(18) Condenser fan shall be direct drive protected by heavy gauge rust resisting wire guard.

(19) To ensure the liquid refrigerant does not flash when supplying to the various Fan Coil Units, the circuit shall come with a sub-cooling feature.

(20) Oil recovery cycle shall be automatic occurring 1 hour after start of operation and then every 6 hours of operation. No oil equalizing piping is required to be installed among the condensing units.

(21) The refrigerant circuit shall include liquid, gas shut off valves and solenoid valves. The system shall have the capability to control the refrigerant temperature based on the variable heat load value automatically.

(22) Standard accessories for condensing unit shall include the following:

(a) Over current protection for the inverter

(b) Anti-recycling timers

(c) High pressure switch

(d) Control circuit fuses

(e) Crank case heaters

(f) Fusible plug

(g) Thermal protectors for compressor

(h) Thermal protectors for fan motors

(i) Suction and liquid lines shut-off valves

2.20.2.2.2 Evaporator Unit (Air Handling Unit / Fan Coil Unit)

(1) Multiple type and multiple capacity evaporator units shall be available for design can be connected to one refrigerant circuit and controlled individually.

(2) The basic components include a fan, an evaporator coil, filters and an electronic proportional expansion valve.

(3) The fan shall be direct drive centrifugal type with statically and dynamically balanced impellers.

(4) The evaporator coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond. The Coil shall be of a waffle louvre fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.

(5) The filters shall be field supplied as per filter clause. On models where field supply is not possible (wall, floor, under ceiling, cassette type) use filter as supplied with unit.

(6) The electronic proportional expansion valve shall be capable of controlling the amount of refrigerant flow into the unit in response to load variations in the room. The control response will be by Proportional Integral Derivative (PID) type of control algorithm.

(7) Casing shall be made of steel sheet, bonded and finished with baked enamel insulated with 1/2" (12 mm) thick, 40 kg/cu.m. (2.5 lb/cu.ft.) density mat-faced fiber glass or steel. The casing may be made of aluminum or fiberglass with equivalent strength.

(8) Evaporator coil shall be seamless copper tube with mechanically expanded into aluminum fins. Coils shall be leak tested and pressure tested at 2,069 kPa. (300 psig.)

(9) Electricity characteristic shall be 230V/1Ph/50Hz or 400V/3Ph/50Hz as indicated on the Drawings.

2.20.2.2.3 Cooling Capacity

(1) The cooling capacity and system design condition shall be indicated on the equipment schedule herein or shown on the Drawings.

(2) If the system design condition not shown, the cooling capacity shall be matching capacity of condensing unit and air handling unit, based on the following conditions :

(a) Air on condenser - dry bulb temperature 35° C (95° F)

(b) Air on evaporator - dry bulb temperature 26.7° C (80° F)

- wet bulb temperature 19.4° C (67° F)

(c) Maximum face velocity of air through evaporator 2.54 m/s (500 ft/min)

2.20.2.2.4 Centralized Control

(1) A centralized control system shall be adopted for the control and monitoring of building air-conditioning system.

(2) The function of the central remote controller shall be as follows:

(a) It should be able to control maximum up to 64 groups (each group consists of maximum up to 16 Indoor Units) or 128 numbers of evaporator units.

(b) Temperature setting for each Indoor Unit or group

(c) Air flow setting for each Indoor Unit or group

(d) Fault indication of each Indoor Unit

(e) Zone control

(f) It should be able to On/Off each individual or group

(g) It should also have the function to On or Off the entire system

(h) Maximum wiring length of 1,000m

(3) The Unified On/Off Controller should be able to connect up to 16 groups (each group consists of maximum up to 16 Indoor Units) or 128 numbers of Indoor Units

(4) The unified on/off controller should have the following functions:

(a) Simultaneously or individually operate the Indoor Unit.

(b) Normal operating status such as normal operation, alarm indication.

(c) Able to have centralized control indication.

(d) It must be able to combine with the Centralized Remote Controller.

(e) Maximum wiring length of 1,000m.

(5) The Schedule Timer should be able to connect up to 64 groups (each group consists of maximum up to 16 Indoor Units) or 128 numbers of Indoor Units

(6) The schedule timer should have the following functions:

(a) It should be able to set 8 types of weekly schedule

(b) Maximum 48 hours backup power supply

(c) Able to have centralized control indication

(d) It must able to be connected to either Centralized Remote Controller or Unified On/Off controller

(e) Maximum wiring length of 1,000m

2.20.2.2.5 Refrigerant Pipe

(1) The refrigerant pipe shall be copper tube hard drawn type L or de-oxidized phosphorous seamless copper pipe conforming to JIS H300 - C1220T. Both suction gas and liquid lines should be sufficiently insulated to prevent formation of condensation in all circumstances.

(2) All the shut off valves connections in the evaporator units shall be brazed to avoid chances of refrigerant leakages (conventionally shut off valves are flanged or flared).

(3) Appropriate refrigeration installation tools must be utilized to avoid the use of elbows. Oxygen free dry Nitrogen (OFN) must be in the system during brazing (no cold brazing is allowed).

(4) All pipe work (suction and liquid) to be insulated with slip on close cell electrometric pipe insulation fire rated to Class "O", with a wall thickness of not less than 25mm. Insulation must be protected when exposed to atmosphere by pipe jacket or special paint or covered by an enclosure.

(5) All branch shall be installed with branch fitting supplied by the same supplier of the system

2.20.3 Execution

2.20.3.1 Installation

2.20.3.1.1 The VRF air conditioner shall be mounted on vibration isolators and installed in accordance with the manufacturer's recommendation such that no disturbing vibration or noise is being transmitted to the nearby structure.

2.20.3.1.2 Refrigerant pipes that exposed to outdoor shall be cover with aluminium pipe jacket or special paint or covered by an enclosurefor protected insulation from direct UV exposure.

2.20.3.1.3 After installation of pipe work, prior to connection to the condensing units, sealing of insulation joints and starting of equipment, pipe work should be pressure tested using oxygen free dry nitrogen as out lined below to 38 Bar (551 Psi), held for 24 hours and checked for leaks.

2.20.3.1.4 Condensing units shall be connected using a torque wrench to tighten to the correct specified toque (see table below) where appropriate.

2.20.3.1.5 The system shall then be vacuumed/dehydrated to 0.2 torr (-755mmHg) and held at that setting for 1 hour (minimum) to 4 hours depending on pipe length using a 2-stage vacuum pump. All of the above works shall be carried out before electrical connection is made to the fan coil units.

2.20.3.1.6 The additional refrigerant charge shall be calculated and weighed to accommodate the actual installed and measured length of pipe work all in accordance to manufacturer's recommendations and instructions listed in the Manufacturer's Installation Instructions.

2.20.3.1.7 The charging should be carried out with an appropriate charging station in the liquid phase and under supervision.

2.20.3.2 Testing and Commissioning

2.20.3.2.1 After installations are completed, all evaporator unit shall undergo test run. Any adjustments that are needed shall be made to assure that all air handlers will operate either the required performance. Report forms to contain following minimum data listings shall include design and actual conditions for each Item mentioned below:

(1) Date and time of test.

(2) Air handling unit and fan coil unit make, type, name and serial number.

(3) Fan rpm.

(4) Pressure drop across filter

(5) Fan discharge static pressure

(6) Fan motor amperage

(7) Rated motor amperage, starter number and ampere rating.

(8) Re-circulated air CFM

(9) Outside air CFM

(10) Outside conditions (DB and WB)

(11) Return air conditions (DB and WB)

(12) Entering coil conditions (mixing) (DB and WB)

(13) Leaving coil conditions (DB and WB)

2.20.3.2.2 During test run, the air filters of testing sets shall be used.

2.21 PRECISION AIR CONDITIONER

2.21.1 General

2.21.1.1 General Requirement

2.21.1.1.1 The Private Party shall furnish and install the precision air conditioner as shown on the Drawings and/or specified herein.

2.21.1.1.2 The precision air conditioner shall be specially designed for 50 Hz. electrical systems and the cooling capacity shall not be less than that indicated on the Drawings.

2.21.1.1.3 Evaporator unit, condensing unit, refrigerant pipe, filter drier, sight glass, shall be installed in the position indicated on the Drawings or advised by the manufacturer.

2.21.1.2 Standards and References

2.21.1.2.1 The precision air conditioner shall comply with the following codes and standards.

(1)	ANSI/ASHRAE 128	:	Method of Rating Portable Air Conditioners
(2)	ANSI/AHRI 210/240	:	Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment
(3)	AMCA 301	:	Method for Calculating Fan Sound Ratings from Laboratory Test Data
(4)	EIT 3008	:	Standard for Air-Conditioning and Ventilating System

2.21.1.2.2 In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

2.21.1.2.3 All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

2.21.1.2.4 The standards and codes as mention in 1.2.1 can be equivalent by another standards and codes, if it equal or better than standards and codes mention in 1.2.1 when comply between two codes.

2.21.1.3 Submittal

The Private Party shall submit precision air conditioner performance sedation, matching convey, material lists and technical data for approval.

2.21.1.4 Quality Assurance

2.21.1.4.1 All unit components shall be guaranteed by the manufacturer or by the contraction for at least two years after handover.

2.21.1.4.2 All compressors shall be guaranteed by the manufacturer as least 3 years.

2.21.1.4.3 The equipment manufacturer plant shall be ISO 9000 certified

2.21.2 Material

2.21.2.1 Description

2.21.2.1.1 The air conditioning equipment shall be air cooled, spit system suitable for HFC-407c, HFC-410a or any zero ODPrefrigerant, factory tested, evacuated dehydrated and pressurized with refrigerant holding charge for field installation. The unit shall be in accordance with the following Specifications as stated below.

2.21.2.1.2 Precision air conditioner shall be extendable modular type. Each module is provided with its own air section, electrical section and cooling section. They shall be design for maintenance access from the front.

2.21.2.1.3 Type of precision air conditioner shall be specified as shown on the Drawings. General classification type of the units shall be as follows:

(1) Classify by air flow direction

(a) Down flow : The units will be discharge cold air on the bottom and intake air (return air) on the top.

(b) Up flow : The units will be discharge cold air on the top and intake air (return air) on the front.

(2) Classify by cooling system

(a) Air cooled direct expansion (DX) refrigerant cooling system with remote air cooled condenser.

(b) Chilled water cooling system.

(c) Water cooled direct expansion (DX) cooling system with water cooled condenser.

(d) Dual circuit cooling system, this type is integrated of two system are describe above in one unit. They will be (a)+(b) or (b)+(c).

2.21.2.2 Component

2.21.2.2.1 Indoor air unit

The indoor air unit shall consist of the following:

(1) Frame and Housing

(a) The unit consists of a frame made of natural color aluminum extruded profile and inner steel walls serving for air direction of highest stability.

(b) The unit is closed on all sides with removable doors. All parts of housing which are in direct contact with water are made of aluminum and lifetime protect against corrosion.

(2) Exterior Panel Work

(a) The panel work is lined out with a noise absorbing insulation, which is thermally treated. The thickness of insulation is minimum 32 mm (1.1/4”).

(b) Panels are designed to a total air pressure difference of minimum 1000 Pa(4”WG).

(3) Evaporator

(a) The evaporator shall be seamless copper tube with mechanically expanded into aluminum fins. Coils shall be leak tested and pressure tested at 2,069 kPa. (300 psig.)

(b) The evaporator coil shall be inclined position and aluminum condensate drain pan.

(4) Fan and Blowers

(a) Fan shall be of the centrifugal type, forward curved blade type mounted on a single shaft. It shall be of the double width, double inlet type low revolutions and low noise emission or plug fan.

(b) Fan housing shall be of heavy gauge galvanized steel, die-formed with stream-lined inlets designed to eliminate eddy and shock.

(c) The fan wheel or impeller shall be of mild steel, fabricated construction and well formed shroud and shall be both statically and dynamically balanced. Shafts shall be steel, either solid or hollow, and ground to close tolerances on all working surfaces. Shafts shall operated well within their critical speeds.

(d) Bearing shall be of the self-aligning, maintenance free pre-lubricated, sealed type, mounted in cast-iron housing, and shall have balls and races specially lapped and individually tested and selected for quiet operation.

(e) Bearings shall be equipped with externally accessible grease fittings and shall be of a size designed to assure an average operating life in excess of 100,000 hours.

(5) Motor and Drive

(a) Both fan and motor shafts shall be provided with proper size grooved pulleys for belt drive with belt guard. Belts shall be of the oil-resistant type and sized for 115 per cent of the rated kW.

(b) Each motor for a V-belt drive shall be fitted with variable pitch pulleys. The pulleys shall be key-slotted and set-screwed to the shafts. All combined parts shall be statically and dynamically balanced. Motor shall be of the totally enclosed fan-cooled type, 1,450 rpm, 400V/3Ph/ 50Hz. insulation class B and protection class IP54.

(6) Compressor

(a) Compressor shall be hermetic type. All compressors shall be mounted on vibration isolators on the unit housing. They shall be equipped with internal overload (overheated) protectors.

(b) Compressor and other heat emitting components shall be located separately from the air stream

(c) The accessories for refrigerant circuit shall be provided and installed completely from factory i.e. filter dryer, sight glass with moisture indicator, thermostatic expansion valve, high and low pressure switch.

(d) Electricity characteristic shall be 230V/1Ph/50Hz or 400V/3Ph/50Hz as indicated on the Drawings.

(7) Heater

(a) Electrical reheat shall installed per module, made of chrome-nickel steel finned rods, fins made of chrome-nickel steel to reduce surface temperature and frame made of galvanized steel.

(b) Each stage is protected by an overheat thermostat and an addition circuit breaker in electrical box in the module.

(8) Humidifier

(a) Steam humidifier shall be installed per module with a nominal pressure is 1-6 bars. Stream capacity shall be in the range of 25-100% of the nominal capacity adjustable on the unit. Completely steam cylinder with the boiling electrodes.

(b) The humidifier is separated from the airflow stream and can be service without interrupting the operation of the unit.

(9) Water Leak Detector

(a) The water leak detector sensing cable provided completed with the unit module. The sensing cable are installed under raised floor and detect water leakage under the unit. The cable detects the presence of water at any point along their length.

(b) The sensing cable constructed of 2 sensor wires and continuity wire embedded in a Fluoropolymer carrier rod. The cable structure has no alarm error when touching any steel

2.21.2.2.2 Air Cooled Condenser Unit

(1) The air-cooled condenser shall be one condenser per refrigerant circuit.

(2) The condenser made of corrosion resistant aluminum casing, suitable for horizontal or vertical installation.

(3) Condenser coil shall be seamless copper tubes with mechanically expanded into aluminum fins, leak tested and pressure tested at 3,100 kPa. (450 psig.).

(4) Condenser fan shall be direct drive protected by heavy gauge rust resisting wire guard.

(5) Fan motor shall be permanent-split-capacitor, inherently protected, permanently lubricated bearings.

(6) There shall be low and high sides access valves for pressure measuring.

(7) Terminal box for power input shall be water protected IP54.

2.21.2.2.3 Master Controller

(1) The controller produces by the same manufacturer as precision air conditioner. The controller is provided for controlling of and a precision air conditioner unit and supervising of room temperature and humidity limits.

(2) The controller can control the operation of stand-by module and duty module by the configuration at least:

(a) Fault Start : The stand-by module will automatic changeover in the unlikely even of failure of duty mode.

(b) Alarm Start : The stand-by module will be start automatically to maintain the room condition in the case of temperature or relative humidity out of limited value.

(c) Sequencing : The automatic duty sharing between stand-by module and duty module ensures all module have the same operating time. Thus each module takes over the stand-by function for a defined time.

2.21.2.2.4 Front Panel / Display Face

(1) Front panel equipped with user friendly large surface LCD display. The software is structured in tree different levels: Information, Operation and Service, which can be operated by a user friendly windows base via the display and the keys consists of;

(a) Selector Button : Select manus and change parameter

(b) Confirmation : Acknowledge function and parameter

(c) On/Off Switch : On/Off

(d) LED Alarm : LED lights up in the event of alarm

(e) Audible Indicator : The audible indicator issues and alarm tone when the alarm signals in the display.

(2) The controller have to display at least:

(a) Actual values of temperature and relative humidity and display of the temperature and humidity curve over at last 24 hours.

(b) Symbols for operation modes cooling, reheat, dehumidification and humidification of every modules.

(c) The RS232 provide for printer interface or for interface with building management system (BMS).

(d) The graphic display can be switch to various languages and different character including both English and Thai.

(e) Module and component running time.

(f) The previous 60 alarms with date and time, alarm delays adjustable, priorities of the alarm.

(g) Maintenance request symbol appear when the service required.

(h) The alarm signals have to transmit via the controller (front panel), paper, mobile phone and fixed line. The front panel alarm with LED indicator and audible alarm with the following display at least:

(i) Temperature too high / too low

(ii) Humidity too high / too low

(iii) Clogged filter

(iv) Compressor high / low pressure

(v) Water leak alarm

2.21.2.2.5 Supervisor Controller

(1) The Supervisor controller produces by the same manufacturer as precision air conditioner unit. Each controller has to provide complete with own supervisor controller.

(2) The supervisor controller acts as a supervisor to the controller and takeover the controller in the event of failure by keeping the same parameter and all features as master controller and front panel and every module still operation with current status.

2.21.3 Execution

2.21.3.1 Installation

2.21.3.1.1 The precision air conditioner shall be mounted on vibration isolators and installed in accordance with the manufacturer's recommendation such that no disturbing vibration or noise is being transmitted to the nearby structure.

2.21.3.1.2 Refrigerant pipes that installed outdoor shall be cover with aluminium pipe jacket for protected insulation from direct UV.

2.21.3.1.3 Installation shall conform to the drawing. Condensing unit shall be supported with steel and rubber to the frame and covered with rustproof and external paint.

2.21.3.1.4 Location of on/off switch and thermistor or temperature controller shall be installed on drawings or manufacturer standard, In case of installation problems that cannot be mounted as indicated, supervisor shall indicated the proper location for installation.

2.21.3.1.5 Vibration isolator shall be provided and noise control shall be concerned for installing each air-conditioning unit.

2.21.3.1.6 Conduit of Electric wiring shall be metal tube. EMT-type shall be installed within indoor area. And IMC Type shall be installed outdoor area.

2.21.3.1.7 Conduit of transmission wiring shall be the type of conduit of Electric wiring tube.

2.21.3.1.8 Connection of conduit shall be waterproofed flexible for outdoor area and normally flexible for indoor area.

2.21.3.1.9 The fuse or non-fuse safety switch for each system shall be installed as near as possible to the condensing unit and be of a suitable capacity as recommended by the a/c equipment manufacturer.

2.21.3.1.10 Power cables (including power supply to air conditioner) and signal cables must not be laid inside the same conduit (Power cables and signal cables must each have their own individual conduits)

2.21.3.1.11 Interlocking system shall be provided for condensing unit and fan coil unit in operation, while fan coil unit is off or condensing unit in operation before fan coil Fuses shall be provided in control system.

2.21.3.2 Testing and Commissioning

2.21.3.2.1 Operating test run shall be provided from manufacturer.

2.21.3.2.2 After installations are completed, precision air conditioner shall undergo test run. Any adjustments that are needed shall be made to assure that all precision air conditioner will operate either the required performance. Report forms to contain following minimum data listings shall include design and actual conditions for each Item mentioned below:

(1) Date and time of test.

(2) Air handling unit and fan coil unit make, type, name and serial number.

(3) Fan rpm.

(4) Pressure drop across filter

(5) Fan discharge static pressure

(6) Fan motor amperage

(7) Rated motor amperage, starter number and ampere rating.

(8) Re-circulated air CFM

(9) Outside air CFM

(10) Outside condition (DB and WB)

(11) Return air condition (DB and WB)

(12) Entering coil conditions (mixing) (DB and WB)

(13) Leaving coil conditions (DB and WB)

2.21.3.2.3 During test run, the air filters of testing sets shall be used.

SECTION 3
PLUMBING WORKS

3.0 GENERAL SPECIFICATION FOR PLUMBING SYSTEM

3.0.1 General

3.0.1.1 Introduction

(1) This general specification and requirement describe the materials and installation of the Plumbing works for building services works and related work for the Project.

(2) The work shall be executed to completion and in conformity with this specification.

3.0.1.2 Operation

(1) Where the Private Party propose to use material and/or equipment which is not specified or detailed on the drawings, the matter shall be brought immediately to the attention of the Engineer's Representative who will make a decision.

(2) The locations of air outlets, air duct route and piping route shown on the drawings are diagrammatic, and shall be considered as approximate only. The approved locations may be different from those shown on the drawings, if so directed by the Engineer's Representative.

3.0.1.3 Environment

(1) The material and equipment shall be installed suitable for tropical climate as mentioned below.

(2) Weather conditions for material and general equipment selection :

(a) Altitude : Approximately mean sea level

(b) Maximum temperature : 40°C (104°F)

(c) Average temperature (all year) : 30°C (86°F)

(d) Maximum relative humidity : 85%

(e) Average relative humidity (all year) : 60%

3.0.1.4 Standards, Codes and Regulations

(1) The entire system and its basic components shall conform in all respects to the standards and regulations of Metropolitan Water Work Authority. The following standards are mentioned in these Specifications for systems and/or components and, where described, the systems and/or components shall conform to such standards.

(a) ANSI - American National Standard Institute

(b) API - American Petroleum Institute

(c) ASHRAE - American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc.

(d) ASPE - American Society of Plumbing Engineer.

(e) ASTM - American Society of Testing Materials

(f) BS - British Standard

(g) DIN - Deutsher Industrie Normen (German Industrial Standard)

(h) EIT - The Engineering Institute of Thailand

(i) FM - Factory Mutual

(j) IEC - International Electro Technical Commission

(k) MEA - Metropolitan Electricity Authority

(l) MWWA - Metropolitan Water Works Association

(m) NEC - National Electrical Code

(n) NFC - National Fire Code

(o) NEMA - National Electrical Manufacturers Association

(p) NFPA - National Fire Protection Association

(q) PEA - Provincial Electricity Authority

(r) TISI - Thai Industrial Standard Institute

(s) UL - Underwriter's Laboratories, Inc.

(t) VDE - Verband Deutsher Electro techniker (German Electrical Regulation and Codes)

(u) Any regulations issued by local authorities.

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

11.0.1.5 Scope of Work

(1) The scope of work of the Private Party shall include provision, installation, testing and balancing, commissioning of equipment and accessories as shown on the Specifications to achieve a complete sanitary system.

(2) The system shall include the following:-

(a) Cold water supply system

(b) Sanitary drainage, soil water, wastewater, drain and vent systems

(c) Wastewater treatment plant system

(d) Hot water system

(e) Rain water drainage system

(f) Building drainage system (site drain)

(g) Electrical power and control

(h) Accessories as required to complete the system

(3) It shall be the Private Party's responsibility to provide a completely safe and workable system in accordance with the requirements of these Specifications, and the accompanying schedules all to the entire satisfaction of the Engineer's Representative.

(4) The Private Party shall coordinate with other trades to ensure that the system and its components furnished form a complete electrical and communication system with the established construction schedule.

3.0.1.6 Examination of Drawings and Specifications

(1) The Private Party shall examine all Drawings and Specifications to make sure that all requirements are thoroughly understood. In cases where, in his opinion, there are omissions and/or errors in any of these documents, he shall inform the Engineer's Representative immediately.

(2) The Private Party shall examine all relevant architectural and structural drawings together with all other utilities systems involved in the Project, prior to installation of machines, materials and equipment.

3.0.1.7 Dimensions

(1) Figured dimensions as indicated on the drawings are to be followed and in no case shall dimensions be scaled from the drawings. Wherever possible, dimensions are to be measured from the building.

(2) Before the Private Party commence any works, he shall ensure that dimensions are checked on the site and/or building and agree with those on the drawings.

(3) The Private Party shall be responsible for the accuracy of such dimensions regardless of the comparable dimensions of the drawings.

3.0.1.8 Operation

(1) Where the Private Party propose to use material and/or equipment which is not specified or detailed on the drawings, the matter shall be brought immediately to the attention of the Engineer's Representative who will make a decision.

(2) The locations of air outlets, air duct route and piping route shown on the drawings are diagrammatic, and shall be considered as approximate only. The approved locations may be different from those shown on the drawings, if so directed by the Engineer's Representative.

3.0.2 Material

3.0.2.1 Material and Equipment

(1) All Plumbing equipment, materials and parts used shall be new and unused, of current manufacture, of the highest quality and free from defects or imperfections affecting the performance or life of the item and approved by the Engineer's Representative.

(2) Unless otherwise specifically indicated on the Drawings or in the specification, all materials and equipment shall be installed, with the approval of the Engineer's Representative, in accordance with recommendations of the manufacturer. However, the approval of the Engineer's Representative shall not release the Private Party from his responsibility or his liability regarding the properties of installations.

(3) The Private Party shall protect all electrical equipment, materials and parts during storage and during construction against the ingress of moisture, contamination or corrosion that might damage the finish or lower the electrical integrity of the item.

(4) Certain major electrical equipment defined in the Specifications will be furnished to the Private Party, on site. The Private Party shall assemble, align, level and fix this equipment as instructed by the manufacturer and to the Engineer's Representative satisfaction.

(5) After the material and equipment have been installed completely in accordance with the instructions, the Private Party shall be responsible for protecting the material and equipment from damages.

3.0.2.2 Equipment Deviations

(1) Where the Private Party proposes to use an item of equipment other than that specified or detailed on the Drawings, requiring any redesign of the structure, partitions, foundations, piping, wiring or any other part of the mechanical, electrical or architectural layout, all such redesign, including drawings and detailing required shall be prepared by the Private Party and then approved by the Engineer's Representative.

(2) Where such approved deviation requires a different quantity and arrangement of cable, conduit, and equipment from the specified or indicated on the Drawings, the Private Party shall furnish and install any such cable, conduit, structural supports, insulation, and any other additional equipment required by the system, which approved by the Engineer's Representative.

(3) In reference to inspection, all works rejected by the Engineer's Representative shall be repaired, corrected or replaced to attain good workmanship, and conform to the consented Working Drawings and approved Specifications. Therefore, ample time shall be provided for inspection and, if there is any defective work re-inspection of the Engineer's Representative shall be performed. In the event that the Private Party should fail to carry out necessary changes, then the Engineer's Representative shall have the right to make its own arrangement.

3.0.2.3 Tools and Appliances

(1) Unless otherwise stipulated, the Private Party shall provide any pay for all tools and other facilities necessary for the execution and completion of the works.

(2) If at any time prior to commencement or during the progress of works, tools, equipment and materials, in the opinion of the Engineer's Representative, appear to be insufficient, of inappropriate to secure the required quality of works or proper rate of progress, the Engineer's Representative may order the Private Party to increase their efficiency, improve their character, augment their number or replace with new tools, equipment and materials as required.

3.0.2.4 Nameplates and Identifications

(1) All parts of the installation, which are of interest for its operation and maintenance, shall be provided with nameplates, tags or arrows, especially in enclosed areas, such as ceiling, shafts, and other places accessible for maintenance service.

3.0.2.5 Submittal of Data for Approval

(1) The Private Party shall submit to the Engineer's Representative complete information regarding details of materials and equipment involved, prior to any purchase or manufacturing operation. Any purchase or manufacturing operations carried out prior to obtaining such approval shall be at the Private Party's sole responsibility.

(2) Each equipment information shall be separately submitted by listing all the details and with attached catalogue indicating at least the model, series, size and performance. Such data shall be sufficient detail to enable the Engineer's Representative to identify that particular product and to form an opinion to its conformity to the Specification.

(3) The Private Party shall stamp the name of his company and sign all documents to be submitted for approval.

3.0.2.6 Approval of Materials

(1) Only new materials and equipment shall be incorporated in the Works. All materials and equipment furnished by the Private Party shall be subject to inspections and approval of the Engineer's Representative. The materials and equipment used for the Works shall correspond to the approved makes or other data. Any materials which, in the opinion of the Engineer's Representative, have lower quality than the approved makes shall promptly be removed from the job site.

(2) Whenever requested by the Engineer's Representative, the Private Party shall send materials to be tested by an independent institute selected by the Engineer's Representative.

(3) If these should be an unavoidable necessity to use materials and equipment that deviate from the specification or from approved samples, then the Private Party shall immediately inform the Engineer's Representative in writing and submit the substitute items of equal quality for approval.

3.0.2.7 Detailed Design Drawings

(1) The Private Party shall prepare detailed design drawings in accordance with the SRT's Requirements – Design, comprising complete details of items to be fabricated and works to be installed. These drawings shall be submitted to the Engineer's Representative for approval before proceeding the preparation for Working Drawing.

(2) Detailed design drawings shall be checked and signed by Registered Engineer of the Private Party. All submitted drawings shall indicate the date of submission and the date(s) of revision(s).

(3) All detailed design drawings shall conform to "Outline Design Specification" and including design criteria and design calculation. The design criteria and design calculation shall be checked and signed by Registered Engineer and submitted to the Engineer's Representative for approval.

(4) Size and scale of the detailed design drawings shall be at least 1:100 scale except for enlarged scale details done for clarity, which shall be in conformity with international standards or as directed by the Engineer's Representative.

(5) Where required by the Engineer's Representative, the Private Party shall prepare additional drawings, diagrams, etc., which in the opinion of the Engineer's Representative are considered necessary for a proper execution of the Works.

(6) The approval of the Engineer's Representative never releases the Private Party from his responsibility or his liability regarding the exact dimensions and any further properties of the installations.

3.0.2.8 Working Drawings

(1) After detailed design drawings have been reviewed and approval by Engineer's Representative, the Private Party shall prepare Working Drawings comprising complete details of items to be fabricated and works to be installed. These Working Drawings shall be submitted to the Engineer's Representative for approval before installation.

(2) The drawings shall be checked by the Private Party for accuracy with regard to dimensions taken in the building(s) and shall closely follow manufacturer's recommendations. All submitted drawings shall be signed by the Private Party, and shall indicate the date of submission and the date(s) of revision(s).

(3) In case Working Drawings require modifications for whichever reason, the Private Party has to clearly identify the portion that was modified, and has to indicate the running number of revision every time that a revision-drawing is submitted.

(4) The installation detailed shall be checked with the building works, the structure and other related trades to prevent conflicts that may cause delay of the project.

(5) Size and scale of the Working Drawings shall be at least 1:100 scale except for enlarged scale details done for clarity, which shall be in conformity with international standards or as directed by the Engineer’s Representative.

(6) Where required by the Engineer’s Representative, the Private Party shall prepare additional drawings, diagrams, etc., which in the opinion of the Engineer’s Representative are considered necessary for a proper execution of the Works.

(7) The Private Party shall not proceed his work for a certain part or section, prior to the approval of the Working Drawings.

(8) Approval of the Working Drawings by the Engineer’s Representative shall not be construed as a complete check but will indicate only the general method of installation and its details are satisfactory.

(9) The approval of the Engineer’s Representative never releases the Private Party from his responsibility or his liability regarding the exact dimensions and any further properties of the installations.

(10) Working Drawings submitted without sufficient detailed shall be rejected and new submission shall be required.

3.0.2.9 As-Built Drawings

(1) The as-built drawings shall record all changes arising during the installation and detail all relevant data concerning makes, types, numbers, capacities, sized and quantities, etc.

(2) The Private Party shall submit to the Engineer's Representative 3 sets of prints and 1 set of reproducible drawings.

(3) The Private Party shall submit to the Engineer's Representative 3 sets of DVD or Portable Hard Disk that contained all PDF documents and AUTOCAD file same data as hard copy.

3.0.2.10 Transportation of Materials and Equipment

(1) The Private Party shall submit in advance a transportation schedule of materials to the Engineer's Representative and coordinate preparing passage ways and storage facilities.

(2) The Private Party shall be responsible for all expense incurred during shipping and transporting of material and equipment to the job site. The materials and equipment shall be handled in a manner to prevent warping, twisting, bending, breaking, chipping, rusting and any injury, theft of damage or any kind what so ever.

(3) The Private Party shall submit in advance a transportation schedule of materials to the Engineer's Representative and coordinate in preparing passage ways and storage facilities.

3.0.2.11 Materials and Equipment Storage

(1) The Private Party shall prepare storage areas of sufficient size for all necessary materials and equipment brought to the job site. The storage areas shall be provided with access for inspection and removal of the stored materials and equipment.

(2) Materials and equipment delivered to the Site without suitable storage shall not be accepted.

3.0.3 Execution

3.0.3.1 Temporary Power Supply and Others

(1) The Private Party shall connect electrical wires, telephone wires and water pipe for his own use at suitable connection points and shall bear the expense of usage, which shall be removed upon completion of sections of the Works.

3.0.3.2 Responsibility

(1) The Private Party shall establish, maintain, and supervise all precautions and programs for safety and provide protection to prevent damage, injury or loss to :

(a) All workmen on the worksite and other persons who may be affected thereby.

(b) All works and all materials or equipment to be incorporated herein, whether in storage on or off the site.

(2) As the work proceeds, the Private Party shall progressively remove rubbish and surplus materials away from the construction site and shall maintain his working area in a clean and tidy condition as far as is practicable.

(3) Upon completion of the Works he shall, without delay, remove all his temporary works and buildings, all tools, equipment and surplus materials, and shall clean the whole area affected by his work and leave it ready for immediately occupation.

(4) All materials, equipment and finished works shall be kept in good condition. The completed work shall be the Private Party's property until handed over to the SRT and the Engineer’s Representative.

3.0.3.3 Field Testing

(1) Test all plumbing equipment upon completion of installation to ensure that the equipment operates satisfactorily and to conform to PPP Contract Documents.

(2) Field testing shall be required for all equipment furnished, installed or connected by the Private Party to assure proper installation, setting, connection, and functioning in accordance with the plans and specifications and manufacturer's recommendations.

(3) Testing shall be conducted in the presence of the Engineer’s Representative and, when necessary, under the supervision of equipment manufacturer's field engineer.

(4) All tests recommended by the equipment manufacturer whether specified in this specification or not, shall be included, unless specifically waived by the Engineer’s Representative.

(5) Testing shall include any additional tests issued by the Engineer’s Representative to determine that equipment, material and system meet requirements of the Specifications.

(6) The Private Party shall maintain in quadruplicate a written record of all tests showing date, personnel making test, equipment or material tested, tests performed and results. Two copies of test records shall be given to the Engineer’s Representative.

(7) Private Party shall be responsible for any damage to equipment or material due to improper test procedures or test apparatus handling, and shall replace or restore to original condition any damaged equipment or material.

(8) Safety devices such as rubber gloves and blankets, protective screens and barriers, danger signs, etc. shall be provided by the Private Party and shall be used to adequately protect and warn all personnel in the vicinity of the tests.

(9) The Private Party shall furnish all testing equipment, and furnish temporary power source of proper type for testing purposes when normal supply is not available at the time of testing.

(10) The conduit and wiring system, shall be checked to ensure that the system has been installed in such a way as to provide a safe and reliable system.

(11) Test all miscellaneous equipment furnished by equipment manufacturer as recommended by the manufacturer i.e., circuit breaker, low voltage switchboard, motor (if any) etc unless specifically waived by the Engineer's Representative.

(12) Include all additional tests issued by Engineer's Representative that he deems necessary because of field conditions, to determine that equipment and material and systems meet requirements of these Specifications.

(13) Be responsible for all damage to equipment or material due to improper test procedures or test apparatus handling.

3.0.3.4 Operation and Maintenance Instructions Manual

(1) The manual shall be prepared in hard cover building in sets to be submitted to the Engineer's Representative on acceptance of the completed work.

(a) Section 1 Comprises submittal data of all equipment and materials that have been approved.

(b) Section 2 Comprises catalogues, categorized in groups, complete with installation operations and the maintenance manuals from the manufacturers.

(c) Section 3 Comprises filled out test reports in the field.

(d) Section 4 Comprises spare parts list and recommended spare parts.

(e) Section 5 Comprises maintenance and services schedule, and service and maintenance procedures for individual equipment listed daily, weekly, monthly, quarterly and yearly.

(f) Section 6 Comprises system operation manual

(2) A draft copy of the manual shall be submitted to the Engineer's Representative for approval first.

3.0.3.5 Asset List

(1) General

(a) The Private Party shall produce an asset list of all main equipment. The SRT or Engineer's Representative have an option to include other accessories with consideration of availability on local market, high value and importance to operation.

(b) The Private Party is responsible for developing a data based information of the asset list or use of commercial software for asset management. Software operating system shall be Windows based (Windows 8) or as agreed with the SRT and the Engineer's Representative.

(c) The list data based shall be capable exported to Asset Management Software of the SRT.

(d) The list shall be submitted in conjunction to the Operation and Maintenance Instruction Manual to the SRT or Engineer's Representative for approval.

(2) Asset Data Based Requirement

The Private Party shall develop an asset list form and issued to the SRT and the Engineer's Representative for approval but shall contain information not limited to the following items:

(a) Asset number : Referring to tags installed in each equipment

(b) Equipment unit number

(c) Equipment description : Type and Capacity

(d) Manufacturer, Model number, Serial number, Date manufactured

(e) Expected service life

(f) Service warrantee Information : Start and expire date

(g) Manufacturer contact information

(h) Number of units

(i) Initial value of equipment

(j) Location : Name of building, room and area serve

(3) Asset Number

The Private Party shall install asset numbering labels on all equipment included in the list and shall be in accordance to the Specification stipulated in Equipment Identification and Labeling Section.

3.0.3.6 Works to Completion

(1) The Private Party shall commission, clean down, and leave in full working order the works as specified.

(2) As the installation proceeds the Private Party shall prepare record drawings of the HVAC installation, as built drawing. It will be sufficient to modify these contract drawings showing any amendments to the service which have taken place and submit the marked-up prints to the Engineer's Representative for approval.

(3) The Private Party shall deliver to the Engineer's Representative on completion of the works, manufacturer's literature, specifications, technical information and record drawings for all equipment installed.

3.1 COLD WATER SUPPLY PUMP

3.1.1. General

3.1.1.1 General Requirement

(1) Pumps used for the same function shall be of the same manufacturer.

(2) The unit shall be especially selected to meet the project requirements, from reputable manufacturers.

3.1.1.2 Standards and References

(1) Pumps and accessories shall comply with the following codes and standards.

(a) ASTM A159-83(1993) : Standard Specification for Automotive Gray Iron Castings:

(b) ASTM B584(2000) : Standard Specification for Copper Alloy Sand Castings for General Applications

(c) ASTM B36/B36M(1995) : Standard Specification for Brass Plate, Sheet, Strip, and Rolled Bar

(d) ASTM A48/A48M(2000) : Standard Specification for Gray Iron Castings

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

3.1.1.3 Submittals

(1) The Private Party shall submit Pump's performance selection, material lists and technical data for approval before purchasing.

3.1.1.4 Warranty

(1) All part of the cold water supply pump shall be guaranteed by the Private Party at least 2 years after handover.

3.1.2 Material

3.1.2.1 Description

(1) The cold water supply pump in this section shall include water transfer pump and package water booster pump set.

(2) The Water Transfer Pump

(a) The water transfer pump shall be centrifugal, single stage or multi-stage volute type. They shall be horizontal split case or end suction or vertical inline. They shall be driven by electric motors with flexible couplings. The pumps and motors shall be mounted on steel base plate.

(b) The transfer pump shall be completed with pump starter and control panel with all automatic control function and can be interface to the building management system (BMS).

(c) The pump type shall be as indicated as follows:

(i) Horizontal Split Case Centrifugal Type

- Pumps shall be of the non-overloading, centrifugal, volute type. They shall be of the horizontal split case, double suction type with suction and discharge connections in the lower half of the casing.
- The pump shall allowing removal of the rotating element without disturbing pipe connections and operating at a speed of not over 1500 rpm.

(ii) End Suction Centrifugal Type

- Pumps shall be of the single-stage horizontal end suction centrifugal type, operating at a speed of not over 1500 rpm.
- The pumps shall be designed so that removal of the pump impeller will not interfere with the piping system (back pull-out pump).

(3) Water Supply Pump-Constant Pressure Booster Pump Set

(a) The water supply pumps shall be constant pressures with continuous running operation sequence and of the low energy consumption. The booster pump set shall be pressure switch controlled or variable speed drive controlled.

(b) The entire booster system shall be factory prefabricated on a common structural steel stand with all interconnection piping anti-vibration mounting and wiring completed and operationally tested prior to shipment. Complete package shall also include isolation valves on the suction and discharge at each pump. Galvanized steel suction and discharge pipe manifolds as well as copper tubing with shut-off cocks for gauges and pressure switch, will be furnished assemble.

(c) The booster pump set shall be completed with pump starter and control panel with all automatic control function and can be interface to the building management system (BMS).

(4) Pumps shall be selected for a total efficiency of not less than 65 percent.

3.1.2.2 Component

(1) Centrifugal Pump

(a) Split Case Centrifugal Type

(i) Pumps shall be of the non-overloading, centrifugal, volute type. They shall be of the horizontally split, or vertically spilt, double suction type with suction and discharge connections in the lower half of the casing.

(ii) The pump shall allowing removal of the rotating element without disturbing pipe connections and operating at not over the rated speed.

(b) End Suction Centrifugal Type

(i) Pumps shall be of single-stage horizontal end suction centrifugal type, operating at not over the rated speed.

(ii) The pumps shall be designed so that removal of the pump impeller will not interfere with the piping system (back pull out pump).

(c) In-line Centrifugal Type

(i) Pumps shall be of the single-stage vertical mounted. Split coupled (for all capacity) or close coupled (capacity not more than 500gpm) design, in-line centrifugal type, single suction with volute type casing operating at a speed of not over 1500 rpm.

(ii) The pumps shall be designed so that removal of the pump impeller will not interfere with the piping system (back pull-out pump).

(2) Centrifugal Pump Component

(a) Casings

(i) Casings of all pumps shall be designed for a working pressure of 16 kg/cm2 or 1.5 times the actual discharge pressure, whichever is greater.

(ii) Pressure classification of flange connections shall correspond to casing working pressures.

(iii) Casing material shall be cast-iron, precision manufactured for best performance and long-term duty.

(iv) Water discharge diffusers shall be included to reduce radial torque to the impeller.

(b) Wearing Rings

(i) All pumps having discharge connections larger than 50 mm and operating at more than 2 kg/cm2 total dynamic head shall be provided with casing wearing rings.

(ii) These rings shall be suitable for an individual application. Rings shall be replaceable, and positively keyed to prevent rotation.

(c) Impellers

(i) Impellers shall be one-piece, zinc free bronze and dynamically balanced. Impellers of pumps having 40 mm and larger discharge connection shall be fully enclosed and hydraulically balanced.

(ii) Impellers shall be accurately keyed to the shaft and fixed in an axial position by shaft sleeves and separate snap rings. Impellers shall be fully protected against damage due to reverse rotation.

(d) Shafts

(i) Shafts for pumps with stuffing boxes shall be of stainless steel, (chrome-iron or nickel-iron) extending through the stuffing boxes. Where stuffing boxes are used, shafts shall be provided with water slingers. Shafts shall be designed with high safety precautions to withstand easily the torsional loads with other stresses to which they may be subjected. They shall be so designed that there will be no detrimental vibrational stresses. All shaft threading shall be external to the water passage and stuffing boxes.

(ii) Shafts sleeves shall be keyed to the shaft and extended through the stuffing box. “O” rings or gaskets shall be provided at sleeve ends to protect the shaft from water corrosion. They shall be so designed that no dismantling of the pump casing is required to replace the sleeves.

(e) Bearings

(i) Bearings shall be heavy-duty ball bearing with a minimum average life of 100,000 hours.

(ii) The bearings shall be self-sealed, and housed in malleable-iron housing aligned to a bearing bracket by means of large precision registers.

(iii) Bearing shall be removable without dismantling any rotating element inside the pump.

(f) Stuffing Boxes

(i) Stuffing boxes shall be deep enough for not less than 4 rings of packing and shall have bronze glands.

(ii) Packing shall be suitable in all cases for the service required with proper consideration of water pressure, temperature, temperature changes and sediment carried in the water.

(iii) Mechanical seals shall be provided in lieu of stuffing boxes as specified in pump schedules. Balance type mechanical seals shall be used when the casing working pressure exceeds 10 kg/cm2.

(g) Couplings

(i) All pumps, other than close coupled pumps, shall be provided with urethane flexible couplings or steel pins and bushing with a service factor of at least 1.5 for an individual application.

(ii) Spacer couplings shall be required for back pull out end suction pumps.

(iii) Couplings shall impose no restriction on normal end play or expansion. Suitable coupling guards shall also be provided.

(h) Base Plates

(i) Each flexible coupled pump shall be provided with a cast-iron or fabricated mild steel base plate to hold both the pump and the motor in correct alignment.

(ii) Pumps and motors shall be accurately aligned.

(i) Miscellaneous Fittings

(i) High points of pump casings shall be provided with air vent cocks. These cocks shall be extended outside of any insulation. Low points of casings shall be provided with valve drains and both inlet and outlet connections with properly located gauge tapings.

(ii) Casing brackets of pumps equipped with stuffing boxes shall be arranged to form drip pockets. A drip pipe shall be run form each drip pocket to the nearest drip funnel or floor drain.

(j) Motors

(i) Each pump shall be driven at the rated speed, 380V / 3 ∅ / 50 Hz. totally enclosed fan-cooled, insulation class F and protection class IP54 electric motor and IP 55 for outdoor motor. The rated kW shall be at least 1.15 times of the maximum power required.

(ii) The rated kW shall be at least 1.15 times the maximum power required

(iii) The motors shall be of a high efficiency design and should be supplied as an integral part of the pump. The Private Party shall submit technical data for approval.

(iv) Bearing of each motor shall be of anti-friction type ball bearing or roller bearings.

(v) Motor terminal box shall be waterproof.

(3) Instrumentation and Control Panel for Transfer Pump

The transfer pump shall included the following instrument and control features:-

(a) Main selector switch “Auto-Off-Manual”

(b) Pressure gauge and pressure switch

(c) Over temperature protection

(d) Flow sequencing

(e) Standby pump sequence and alarm

(f) Lead-lag pump selector switch

(g) Thru the door pump disconnect switch

(h) Pump run light

(i) External overload reset

(j) Control power light and switch

(k) Audible alarm horn

(l) Water storage tank low level system shut down

(m) High system alarm

(n) Control panel

(o) Pressure regulating valve

(p) Gate vale, check valve

(q) Strainer

(r) Flow switch

(s) Pump overload light

(t) Flexible Connectors.

(u) Storage tank level switch

(v) Roof tank level switch

(4) Instrumentation and Control Panel for Constant Pressure Booster Pump Set

The booster pump set shall included the following instrument and control features:-

(a) Main selector switch “Auto-Off-Manual”

(b) Pressure gauge and pressure switch

(c) Over temperature protection

(d) Flow sequencing

(e) Standby pump sequence and alarm

(f) Lead-lag pump selector switch

(g) Thru the door pump disconnect switch

(h) Pump run light

(i) External overload reset

(j) Control power light and switch

(k) Audible alarm horn

(l) Water storage tank low level system shut down

(m) High system alarm

(n) Variable speed drive (for Variable Speed Booster Pump Set only)

(o) Pressure transmitter (for Variable Speed Booster Pump Set only)

(p) Control panel

(q) Pressure regulating valve

(r) Gate vale, check valve

(s) Strainer

(t) Anti-Vibration pads

(u) Flow switch

(v) Pump overload light

(w) Flexible Connectors.

(x) Diaphragm tank, pre-charged diaphragm type closed pressure tank.

3.1.2.3 System Control

(1) Cold Water Transfer Pump

(a) The transfer pump shall be controlled by storage tank and roof tank level switch.

(b) The transfer pump controlled shall be parallel and alternated, when the lead pump can not handle the volume flowrate of the system then the lag pump will be automatically start to run parallel.

(2) Constant Pressure Booster Pump Set

(a) System pressure controlled shall be maintain within + 5% by pilot operated diaphragm type, combination pressure regulating and non-slam check valve on each pump discharge line, or stabilized and controlled by a pressure reducing valve station using a small pressure regulating valve for low flow requirements and a large valve for medium to large capacities.

(b) The booster pump set shall be controlled by storage tank level switch.

(3) Variable Speed Booster Pump Set

(a) System pressure shall be maintain within + 5% by variable speed drive (Inverter) and pressure transmitter (At the longest point of riser) and non-slam check valve on each pump discharge line.

(b) Pump shall be stabilized and controlled by a pressure reducing valve station using a small pressure regulating valve for low flow requirements and a large valve for medium to large capacities.

(c) The booster pump set shall be controlled by storage tank level switch.

3.1.3 Execution

3.1.3.1 Installation

(1) Pumps shall be installed by following the manufacturer recommendations and general practiced of pump installation.

(2) Each pump shall be mounted on approved vibration isolators which are, in turn, placed on a concrete base. The isolators shall be selected and installed in accordance with the manufacturer's recommendations such that no disturbing vibration and noise is being transmitted to the nearby structure.

(3) Ensure that no cavitation occurs at the eye of the impeller

(4) Any suction and discharge pipes, which are bigger than the pump connections shall be equipped with eccentric reducers.

(5) Flexible connections shall be installed on both the suction and on the discharge pipe.

(6) Shut-off valve and strainers shall have the same size as the suction pipe. Check valve and shut-off valve shall have the same size as the discharge pipe.

(7) Drainage from each pump shall be discharged to the nearest drain. Each drain pipe shall be of galvanized steel pipe as detailed within this specification.

3.1.3.2 Testing and commissioning

(1) Operating test run shall be provided from manufacturer

(2) Before start-up, grease or lubricating oil shall be applied to the pump and motor.

(3) After installations are completed, all pumps shall undergo test run. Any adjustments that are needed shall be made to assure that all pumps will operate either the required performance. Report forms to contain following minimum data listings shall include design and actual conditions for each Item mentioned below:

(a) Date and time of test.

(b) Ambient conditions at time of test.

(c) Pump maker, type, name and serial number.

(d) Pump rpm.

(e) Pump amperage (Individual Operation).

(f) Pump amperage (Multiple Operation).

(g) Rated motor amperage, starter relay number and amperage rating.

(h) Pump inlet pressure (Individual Operation).

(i) Pump inlet pressure (Multiple Operation).

(j) Pump outlet pressure (Individual Operation).

(k) Pump outlet pressure (Multiple Operation).

(l) Water flow rate GPM.

3.2 WATER HEATER

3.2.1 General

3.2.1.1 General Requirement

(1) Water heater used for the same function shall be of the same manufacturer.

(2) The unit shall be especially selected to meet the project requirements, from reputable manufacturers.

3.2.1.2 Standards and References

(1) Water heater and accessories shall comply with the following codes and standards.

(a)	ASHRAE 90.1(1999)	:	Standard for energy efficiencies
(b)	ASTM B584(2000)	:	Standard Specification for Copper Alloy Sand Castings for General Applications
(c)	ASTM B36/B36M(1995)	:	Standard Specification for Brass Plate, Sheet, Strip, and Rolled Bar
(d)	ASTM A48/A48M(2000)	:	Standard Specification for Gray Iron Castings

3.2.1.3 Submittals

(1) The Private Party shall submit Water heater's performance selection, material lists and technical data for approval before purchasing.

3.2.1.4 Warranty

(1) All part of the water heater shall be guaranteed by the Private Party at least 2 years after handover.

3.2.2 Material

3.2.2.1 Description

(1) The Private Party shall provide all equipment, installation and adjustment of the water heater size is specified herein.

(2) Material and equipment to be supplied shall be the standard products of a manufacturer regularly engaged in manufacturing the products conforming to the Specification.

3.2.2.2 Component

(1) Storage Water Heater

(a) Electric heater shall be glass-lined storage tank made from heavy duty steel tank with working pressure of 1,034 kPa. (150 psi.). The tank shall be factory assembled and wired.

(b) The tank shall be equipped with electric heater elements, anode rods for cathodic protection, automatic temperature control, thermostats, temperature and pressure relief valve, and completed with electrical wiring.

(c) The control shall be provided for safety shut-off in case of overheat temperature and storage of water.

(d) The tank shall be insulated with high density glass fibre insulation and outer wrapped with baked enamel steel jacket and complete assembled from the factory.

(e) The main equipment for electric water heater shall be equipped with the following:

(i) Main circuit breaker for each unit.

(ii) Terminal block.

(iii) Integral fusing for each element.

(iv) Magnetic contactor.

(v) Electric heating elements.

(vi) Automatic temperature control.

(vii) Immersion thermostat or surface mounted thermostat one for each heating element.

(viii) The 220 volt control circuit with fuse.

(ix) Power supply is 220Volt/ 1 Phase/ 50 Herz or 380 Volt/ 3 Phase/ 50 Herz as specified on the equipment schedule.

(x) Complete electrical wiring and grounding screw is provided.

(xi) The storage capacity as specified on the equipment schedule with glass-lined storage tank with anode rod for cathodic protection.

(xii) High density fiberglass insulation.

(xiii) Service handhole cleanout.

(xiv) Temperature and pressure relief valve.

(xv) Thermometer.

(xvi) Hot water outlet connection.

(xvii) Cold water inlet connection.

(xviii) Drain valve.

(xix) Other accessories for complete system.

(2) Instantaneous Electric Water Heater

(a) The instantaneous electric water heater shall be compact design to produce hot water at the rate of not less than indicated on the equipment schedule.

(b) The power for heating element shall be as specified on the equipment schedule.

(c) The power supply is 220Volt/ 1 Phase/ 50 Herz or 380 Volt/ 3 Phase/ 50 Herz as specified on the equipment schedule.

(d) The unit shall equipped with on/off temperature adjustable control knob, high temperature thermal cut off and pressure sensor to switch off if water flow is too low.

(e) The unit is to be complete with a stainless steel flexible hose and rose.

3.2.3 Execution

3.2.3.1 Installation

(1) The entire unit is to be wired and installed strictly in compliance with the manufacturer's recommendations.

(2) The water heater shall be ground to building grounding system.

(3) Installation shall be followed instruction manual from manufacturer.

3.3 SEWAGE PUMP SETS

3.3.1 General

3.3.1.1 General Requirement

(1) Pumps used for the same function shall be of the same manufacturer.

(2) The unit shall be especially selected to meet the project requirements, from reputable manufacturers.

3.3.1.2 Standards and References

(1) Pumps and accessories shall comply with the following codes and standards.

(a)	ASTM A159-83(1993)	:	Standard Specification for Automotive Gray Iron Castings:
(b)	ASTM B584(2000)	:	Standard Specification for Copper Alloy Sand Castings for General Applications
(c)	ASTM B36/B36M(1995)	:	Standard Specification for Brass Plate, Sheet, Strip, and Rolled Bar
(d)	ASTM A48/A48M(2000)	:	Standard Specification for Gray Iron Castings

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

3.3.1.3 Submittals

(1) The Private Party shall submit Pump's performance selection, material lists and technical data for approval before purchasing.

3.3.1.4 Warranty

(1) All part of the booster pump shall be guaranteed by the Private Party at least 2 years after handover.

3.3.2 Material

3.3.2.1 Description

(1) The sewage pump in this section shall include drainage pump, sewage pump, and aerator.

(2) Submersible Drainage Pump

(a) Submersible drainage pump shall be of the automatic, electrical-motor-driven submerged type, complete with all necessary control equipments.

(b) The use of guide rail with fitting with the pumps in the sump has made the removal and installation easier by suspending with the chain.

(c) The submersible drainage pump shall be completed with pump starter and control panel with all automatic control function and can be interface to the building management system (BMS) and SCADA system.

(3) Submersible Sewage Pump

(a) The submersible sewage stationary pump shall meet the following requirements, submersible sewage pump with cutter device, with torgue-flow impeller and submersible chemical pump.

(b) The submersible pump shall be constructed such that motor is the integral part of the unit and shall be capable of operating in submerged condition without any damage.

(c) The submersible sewage pump shall be completed with pump starter and control panel with all automatic control function and can be interface to the building management system (BMS) and SCADA system.

3.3.2.2 Component

(1) Submersible Drainage Pump

(a) Drainage Pump

The pump shall be of the automatic, electrical-motor-driven submerged type, complete with all necessary control equipments. The use of guide rail with fitting with the pumps in the sump has made the removal and installation easier by suspending with the chain.

(b) Motor

Pump shall be directly connected to a vertical electrical motor having continuous oiling device on packed bearing sealed against dirt and moisture.

The motor shall be class F insulation with built-in thermal protection.

(c) Control

The motor shall be operated by a float switch adjusted to start and stop the motor at predetermined water levels. The switch shall be completely enclosed in a raintight cast-aluminum case. Duplex pumps shall be equipped with and automatic alternator to allow for the change in operation form one pump to the other and for starting the second pump if the flow to the sump exceeds the capacity of the first pump.

(d) Discharge Line and Accessories

The discharge line from each pump shall be provided with a check valve and union in an accessible location near the pump.

(2) Submersible Sewage Pump

(a) The submersible sewage stationary pump shall meet the following requirements, submersible sewage pump with cutter device, with torgue-flow impeller and submersible chemical pump.

(b) The submersible pump shall be constructed such that motor is the integral part of the unit and shall be capable of operating in submerged condition without any damage.

(c) The shaft shall be of mechanical type, lubricated with oil. The sealing effect shall be kept for a long usage.

(d) The pump impeller shall have adequate passage to handle solids, end it shall be hydraulically balanced.

(e) The pump with cutter device shall have a rotating cutting edge and a stationary cutting edge. The rotating cutting edge shall be made of tungsten carbide, and the stationary cutting edge shall be surface-harndened.

(f) The motor shall be submersible type and be capable of running in submerged condition without any damage.

(g) The motor shaft shall be common to the pump shaft.

(h) The bearing shall be able enough to sustain pump thrust and shall maintain it's funcation for a long usage.

(i) The pumps of more than 22 kW. output shall have a leak sensing probe inside the oil chamber.

(j) The pupms of more than 22 kW. output shall have a water jacket by which the motor is cooled by itself.

(k) The cable entry shall be constructed such that water does not leak into the terminal box even along with the cable conductors if the sheath is damage.

(l) Motor protector shall be as follows :

i) D.O.L. start motor shall have a motor protector which is connected in the main circuit of single phase motor winding or neutral point of three phase motor winding. The protector shall be such that, if it senses overheating and/or overcurrent, it automatically cuts the circuitry to stop the motor. The protector shall automatically reset to re-start the pump when cooling down has occurred.

ii) Start-Delta start motor shall have three minieture protectors (thermostat) which are connected in series and embedded on the motor windings. The protectors shall sense motor overheating and give a signal through the cabtyre cable, then actuate on the magnetic contactor in control panel or starter to cut the power supply circuit. The type of contactor of the miniature protectors shall be B-contact.

(m) Material

Pump casing	:	Iron casting, Stainless casting, Bronze casting
Impeller	:	Iron casting, Stainless steel or casting, Bronze casting
Mechanical Sealed	:	SiC (silicon carbide) or WC (tungsten carbide) seal
Shaft	:	Stainless steel
Cabtyre cable	:	P.V.C. Sheathed, Chloroprene sheated
Motor frame	:	Iron casting, Stainless steel or casting

(n) Accessories

(i) Automatic discharge connection components ; Duckfoot bend, support, Guide pipes (Galvanized steel, Stainless steel) and Lifting chain(Galvanized steel, Stainless steel)

(ii) Free-standing type components ; Discharge bend, Pump stand (strainer)

(iii) 5 meters of cabtype cable

(o) Painting

The painting shall be epoxy-tar painting, chloroprene rubber painting or other painting recommended by manufacturer. Stainless steel components shall not be painted.

(3) Submersible Aerator & Ejettor Artator

(a) The submersible aerator & ejetor shall meet the following requirements :

(b) The aerator shall consist of an intergral submersible electric motor and an aerator, and shall be capable of operating in the submerged condition without any damage.

(c) The aerator shall have an impeller and a casing. The operation shall be such, that the rotatiion of impeller shall create a centrifugal force in the casing and through this centrifugal force negatice pressure areas shall be created at the periphery of the impeller, which draws air from the atmosphere. The air sucked down into the water shall be subject to an air/water collision within the guide vane, and chen this mixed air-water current is forcibly discharged through the discharge outlets. The numbers of discharge outlets shall be not less than six (6).

(d) The shaft seal shall be mechanical seal running in an oil bath. A dust seal shall be furnished between the mechanical seal and the impeller, by which ducts in the sucked air shall not come in contect with the mechanical seal.

(e) The sucked air shall pass through an air passage made between the mechanical seal and the back of impeller.

(f) the motor shall be submersible type and be capable of running in submerged condition without any damage.

(g) The motor shaft shall be common to pump shaft.

(h) The bearing shall be able enough to sustain the pump thrust and shall maintain it's function for a long usage.

(i) The cable entry shall be constructed such that water does not leak into the terminal box even along with the cable conductors if the sheath is demaged.

(j) The motor protector shall be as follows :

(i) D.O.L. standard or shall have a motor protector which is connected in the main circuit of single phase motor or meatral point of three phase motor winding. The protector shll such, that if it senses overheating and/or overcurrent, it automatically cuts the circuitry to stop the motor. The protector shall automatically reset to re-start the pump when cooling down has occurred.

(ii) Star-delta start motor shall have three miniature protectors (thermostat) which are connected in serices and embedded on the motor windings. The protectors shall sense motor overheating and give a signal through the cabtype cable, then acturte on the magnetic contactor in a control panel or starter to cut the power circuit. The type of contactor of the miniature protectors shall be 'B-contact'.

(k) Material

Pump casing Iron casting, Stainless steel or casting, Section cover Stainless casting (#304, #316), Impeller Stainless casting (#304, #316), Mechanical Seal SiC (Silicon Carbide), or WC (Tungaten Carbide), Shaft Stainless steel, Cabtyre cable P.V.C. sheathed or Chloroprene sheathed, Motor frame Iron casting, Stainless steel or casting

(l) Accessories

Completed with silencer, air control valve, air inlet pipe, long flexible vinyl suction delivery, stainless steel lifting chain, cabtyre cable.

(m) Painting

The painting shall be epoxy tar, chloroprene rubber, or other painting recommended by manufacturer. Stainless steel components shall not be painted.

3.3.3 Execution

3.3.3.1 Installation

(1) Installation shall be followed instruction manual from manufacturer

3.3.3.2 Testing and commissioning

(1) Before start-up, grease or lubricating oil shall be applied to the pump and motor.

(2) After installations are completed, all pumps shall undergo test run. Any adjustments that are needed shall be made to assure that all pumps will operate either the required performance. Report forms to contain following minimum data listings shall include design and actual conditions for each Item mentioned below:

- (a) Date and time of test.
- (b) Ambient conditions at time of test.
- (c) Pump make, type, name and serial number.
- (d) Pump rpm.
- (e) Pump amperage (Individual Operation).
- (f) Pump amperage (Multiple Operation).
- (g) Rated motor amperage, starter relay number and amperage rating.
- (h) Pump inlet pressure (Individual Operation).
- (i) Pump inlet pressure (Multiple Operation).
- (j) Pump outlet pressure (Individual Operation).
- (k) Pump outlet pressure (Multiple Operation).
- (l) Water flow rate GPM.

3.4 WASTE WATER TREATMENT PLANT

3.4.1 General

3.4.1.1 General Requirement

(1) Waste water treatment plant shall be completely package sewage onsite treatment unit which compact the septic process and/or anaerobic filter process in one unit.

(2) Waste water treatment plant shall be suitable to be used for soil treatment and domestic water treatment to purify waste water before flowing out to public water resources.

3.4.1.2 Standard and References

(1) Purify waste water that flowing out to public water resources shall comply with the laws and local codes or reliable engineering codes.

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

3.4.1.3 Submittals

(1) The Private Party shall submit waste water treatment plant's performance selection, material lists and technical data for approval before purchasing.

3.4.1.4 Warranty

(1) All part of the waste water treatment plant shall be guaranteed by the Private Party at least 2 years after handover.

3.4.2 Material

3.4.2.1 Description

(1) The works shall be executed to completion and in conformity with these Specifications.

3.4.2.2 Component

(1) Anaerobic Wastewater Treatment Plant

Anaerobic wastewater treatment plant shall be Septic-Anaerobic Filter System designed especially for treating wastewater from the toilet bowl, toilet sink, kitchen sink and other waste-water outlets of all types.

(2) Aerobic Wastewater Treatment Plant

Aerobic wastewater treatment plant shall be designed using oxygen to bio-chemically digest the wastewater from toilet bowl, toilet sink, kitchen sink and other waste-water outlets from buildings of all types. The treatment plant shall be packaged system fabricated from fiberglass or polyethylene. The system shall comprises of at least three chambers; settling or solid separation, activated sludge or aeration and sedimentation chambers. The aeration chamber shall be filled with plastic media. The aeration shall be achieved by diaphragm pump or air blower, outdoor type with at least one reserved unit.

(3) Combined Wastewater Treatment Plant

Combined wastewater treatment plant shall be a combination of anaerobic, aerobic, and anoxic biological treatment process which maximizes the efficiency of the micro organisms to digest the organic waste.

(4) Grease Trap

Grease Trap shall be fiberglass or polyethylene with minimum of 2 compartments. The first compartment shall be provided with removable garbage holder to retain garbage, solids and large particles. Grease trap shall be installed with flexible hose for grease drain and removable cover for maintenance.

3.4.3 Execution

3.4.3.1 Installation

(1) Install equipment in accordance with manufacturer's instructions.

3.4.3.2 Testing and Commissioning

(1) Test equipment in accordance with manufacturer's instructions.

(2) The Private Party and manufacturer shall responsible for the commissioning of the system, until the effluent meet the standard.

3.5 COLD WATER SUPPLY PIPING WORK

3.5.1 General

3.5.1.1 General Requirement

(1) The Private Party shall furnish and install all piping work including all necessary parts as specified herein.

3.5.1.2 Standards and References

(1) The piping work shall comply with the following codes and standards.

(a) ASTM D2239(2003) : Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR)

(b) TIS 982-1990 : High-density polyethylene pipes for drinking water services

(c) AWWA C203 : Coal-Tar Protective Coatings and Linings for Steel Water Pipelines

(d) AWWA C901 : Standard for Polyethylene (PE) Pressure Pipe and Tubing for Water Service

(e) BS 1387 (1985) : Medium Black & Galvanized Steel Pipe

(f) BS 143 & 1256 (1986) : Malleable cast iron and cast copper alloy threaded pipe fittings

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

3.5.1.3 Submittals

(1) The Private Party shall submit all material, catalog, material lists and technical data request for approval before installation.

3.5.1.4 Warranty

(1) All part or the piping work shall be guaranteed by the Private Party at least 2 years after handover.

3.5.1.5 Delivery, Handling, Storage and Cleaning

(1) Pipes shall be delivered and stored with plugged ends. Ends shall be kept closed with temporary covers during erection. Before any pipe is installed, it shall be opened and pounded to remove any foreign substances, or swabbed, if necessary, for thorough cleaning.

(2) Pipes shall be stored on racks in a suitable warehouse or cover to avoid rusting. If necessary, carbon steel pipes shall be coated with anodic rust converter or red lead primer.

(3) During the course of installation, the Private Party shall take every precaution to prevent any debris from being left in the pipes. He shall be responsible for any damage that may occur.

(4) Immediately after erection, exposed threads at all fittings shall be painted with zinc-chromate paint, and after welding each joint shall be wire-brushed and then painted with zinc-chromate paint.

(5) Before start-up, all piping systems shall be thoroughly flushed with water until it runs clear.

(6) Fixtures and equipment shall be lightly covered and protected against damage. At the completion of the work, fixtures, materials and equipment shall be thoroughly cleaned and delivered in a satisfactory condition.

3.5.2 Material

3.5.2.1 Description

(1) The cold water piping shall be the types or models, which are suitable for the working fluid in the system.

(2) The rated working pressure of the cold water piping system as specified for the working fluid shall be at least 1.5 times of the actual working pressure, but not less than 1,034 kPa (150 PSIG.).

3.5.2.2 Component

(1) Cold water pipe

(a) Cold water pipe for underground shall be High Density Polyethylene (HDPE) pipe Class PN 10 conforming to ASTM D2239, TIS 982-1990.

(b) Cold Water inside building shall be PE-Lined or PVC-Lined steel pipe

(2) Fittings for High Density Polyethylene (HDPE)

Fitting for HDPE pipes shall be high density polyethylene as requirement or recommendation of manufacture.

(3) Fittings for PE-Lined or PVC-Lined steel pipe

Fitting for PE-Lined or PVC-Lined steel pipe shall follow requirement or recommendation of manufacturer

3.5.3 Execution

3.5.3.1 Installation

(1) General Piping Installation

(a) All piping shall be installed parallel to, or at right angles with, the building walls and partitions. A pitch in the direction of flow and drain shall be not less than 1: 500. Branches from water mains shall be taken in a manner that facilities venting and draining. Reductions in bore shall be formed eccentrically to facilitate venting, except on vertical pipes where concentric reduction may be used.

(b) All water piping shall be installed in such a way that all circuits can be completely drained off and all air pockets in the water circuits shall be suitably vented.

(c) Clearance between pipe works and equipment or machinery shall be adequately provided to facilitate maintenance. Overhead clearance shall be at least 600 mm. over access ways, and where possible the projection of valve stems into access ways shall be avoided. Pipe works and pumps shall be so arranged that the removal for maintenance of the equipment can be carried out with minimum dismantling. Provision of all pipe fittings and accessories necessary for the efficient functioning of the various systems shall be included.

(d) Pipes shall be installed in continuous lengths as long as possible. Except where required to be connected to fitting outlets or headers, they shall be joined by welding, solvent welding, screwing or soldering as approved or indicated in these Specifications.

(e) The equipment or piping shall be installed so that it will not provide a cross connection or interconnection between a distributing supply for drinking or domestic purposes and a polluted supply such as a drainage system or a soil or waste pipe that will permit or make possible the backflow of sewage, polluted water or waste into the water supply system. Where crossing a sewer or waste line is inevitable, the water line shall be not less than 0.30 meters above the sewer line, which shall be cast-iron soil pipe for not less than 30 meters on each side of the crossing.

(f) All pipes shall be installed in an appropriate manner to present a neat and orderly appearance, using fittings for all changes of direction, and arranging pipe run parallel to or at right angles with structural members of the building, to provide utmost head-room and to clear lights and other obstructions. In general, suspended pipes shall be installed as closely as possible to the overhead structure.

(2) Workmanship

(a) All pipes shall be cut accurately to measurements established at the site, and shall be worked into place without springing or forcing.

(b) Piping shall be installed so that it may expand and contract freely without injury to itself or other work. Steel and wrought-iron pipe shall be cut with pipe cutters and threaded with sharp, clean dies. All cut sections shall be reamed to remove all burrs and to restore the pipe to full diameter. All changes in size shall be made with reducing fitting.

(c) Pipe bends and bushings are prohibited.

(3) Location of Device

(a) All valves, cleanouts, equipment, accessories, and devices shall be so located that they are accessible for repair and replacement.

(4) Connection to Equipments

(a) Connections to coils, pumps and other equipment shall be made in such a manner that undue strains between pipes and equipment are eliminated.

(b) Unions and/or flanges shall be used to facilitate the removal of the equipment.

(5) Expansion and Contraction

(a) The piping systems shall be installed so that there will be no damage due to expansion and contraction during operation.

(b) Packless type expansion connectors shall be used where the expansion and contraction of the pipe is excessive or cannot be compensated by expansion loops or offsets.

(6) Differential Settlement

(a) The piping systems shall be installed so that there will be no damage due to differential settlement of the pipe supports after installation. The problems shall be avoided by providing flexible connections.

(7) Sleeves

(a) Vertical pipes passing through floors shall be provided with sleeves of black steel pipes. Sleeves shall be of a proper length to pass through the entire floor construction and shall terminate 50 mm. above the finished floor level.

(b) Horizontal pipes passing through walls and partitions shall be provided with full thickness sleeves made of standard weight black steel pipes.

(c) Sleeves shall be large enough to leave not less than 12.5 mm. clearances around the pipe and covering insulation, if there is any. Sleeves shall be set in place where the walls and partitions are built.

(d) Sleeves in concrete work shall be flanged at the bottom or provided with temporary centering caps and securely nailed or screwed to formwork before the concrete is poured.

(e) Provide chromium-plated escutcheon, where exposed pipes pass through walls or floors.

(f) When sleeves are installed through a fire wall, the clearance between sleeves and pipes shall be filled with fire-resistant material. The fire rating of the fire-resistant material shall be at least equivalent to that of the fire wall.

(g) When pipes pass through waterproof walls, water retaining rings with approved type of sealant shall be applied.

(8) Pipe Joints

(a) Joint for Threaded Pipe

(i) Joints for threaded pipes shall be made with an approved teflon tape or graphite compound applied to the male threads only. Threads exposed after joints are made up shall be mopped with compound.

(ii) Threads shall be of the cleanout, tapered threads with the ends being reamed before installation.

(b) Joint for Flanged Pipe

(i) Flanged joints shall be installed at all valves larger than 50 mm. and at other places where necessary.

(ii) Jointing flanges shall be truly parallel to each other so that bolts are used only to tighten joints, rather than correct alignment. Flanges shall be chosen to suit the maximum working pressure of the system. Bolts, nuts and washers shall be cadmium-plated steel.

(c) Welded Pipe Joint

(i) The edges of the pipe to be welded shall be machine-beveled wherever possible. Gas cuts shall be true and free of all burnt metal. Before welding, the surfaces shall be thoroughly cleaned and degreased. The welding technique shall be such as to ensure penetration to the full thickness of the pipe wall and through fusion of the deposited metal with the parent metal. During welding the ends of the pipes shall be held firmly together by suitable lugs, welded-on-bridge pieces or adequate tack welding. Special care shall be taken to prevent formation of welded obstructions and lodgment of welding residue inside the pipes. Cracks, pinholes, excessive under-cutting, etc. shall be removed and the joints rewelded. Welding materials and workmanship shall be in accordance with AWS.

(ii) Welders must be entirely competent and may be required to perform site tests. Should the Engineer not be satisfied, the welder must be replaced. The Engineer reserves the right to order the cutout for inspection of up to 1 percent of the total number of welds. In the event of any inspected welds being, in the Engineer opinion, unsatisfactory he reserves the right to order the removal of further welds which in his opinion indicate faulty workmanship. Welds removed for inspection shall be reinstalled.

(iii) Either the electric arc or the oxy-acetylene welding method may be used. Welding rods or electrodes shall have such composition that the welds produced by them shall have the same analysis as the parent metal and shall be of an approved type and brand.

(9) Hanger and Supports

(a) All pipes shall be securely supported. Horizontal piping shall be supported by adjustable clevis type hangers with solid rods securely attached to the building structure. Where several pipes run in a parallel fashion, trapeze hangers may be used in lieu of separate hangers. All hangers shall have turnbuckles or other approved means of adjustment. Where pipes, such as those from individual toilet rooms to main stacks, are not low enough to permit the use of turnbuckles, other means of adjustment shall be used. Chains, straps, perforated bars, or wire hangers will not be accepted. All hangers and supports shall be hot-dip galvanized. The maximum distances between hangers and supports for horizontally mounted and vertically mounted pipes shall be as indicated below.

(b) For all pipes where the hanger clips bear directly on pipes and for hangers of dissimilar metals, suitable apparition with a layer of felt shall be provided to prevent corrosion. Hangers on structural steel is absolutely prohibited, unless with the express approval from the Engineer.

(c) Anchors for steel pipes shall be welded directly to the pipe wall and securely bolted to the building structure. Anchors for copper and PVC pipes shall be of the split ring type. Hangers in the plant room shall be supported on springs.

(d) Supporting brackets shall be fastened to concrete by means of inserts or expansion bolts, to brickwork by means of expansion bolts, and to hollow masonry by means of toggle bolts. Two fixings per bracket shall be provided as follows:-

Nominal Pipe Size (mm.)	**Fixing Size (mm.)**
Up to 65 (2 ½”)	6.4 (1/4”)
80 (3”) to 150 (6”)	9.5 (3/8”)
200 (8”) to 300 (12”)	12.7 (1/2”)

(e) All hangers and steel supports shall be zinc coating.

(f) The thickness of coating shall be not less than 300 grammas of zinc per square meter (1 oz per sq.ft.) of the surface covered. Underground pipe support and hanger shall be all stainless steel.

(g) Schedule of Pipe Supports as shown in the following table.

SCHEDULE OF PIPE SUPPORTS							
Nominal Pipe Size (mm.)	Hanger Rod Min. Size (mm.)	Maximum Interval (m.)					
		Steel Pipe		PVC Pipe		Copper Pipe	
		Horiz.	Vert.	Horiz.	Vert.	Horiz.	Vert.
15 (1/2”)	9	2.0	2.4	0.9	1.2	1.5	1.8
20 (3/4”)	9	2.4	3.0	1.0	1.2	1.8	2.4
25 (1”)	9	2.4	3.0	1.0	1.2	1.8	2.4
32 (1 ¼”)	9	2.4	3.0	1.2	1.8	2.0	3.0
40 (1 ½”)	9	3.0	3.6	1.3	1.8	2.4	3.0
50 (2”)	9	3.0	3.6	1.5	1.8	2.4	3.6
65 (2 ½”)	12	3.0	4.5	1.8	2.4	3.0	3.6
80 (3”)	12	3.6	4.5	2.0	2.4	3.0	3.6
80 (3”)	15	4.0	4.5	2.4	2.4	3.6	3.6
100 (4”)	15	4.8	4.5	2.4	3.0		
125 (5”)	22	4.8	4.5	2.4	3.0		
150 (6”)	22	6.0	4.8	3.0	3.6		
200 (8”)	22	6.0	4.8				
250 (10”)	22	6.0	4.8				
300 (12”)	22	6.0	4.8				

(10) Floor, Wall and Ceiling Plate

(a) Furnish and install plates on all entry and exit openings for all exposed pipes passing through finished walls, finished partitions, finished ceilings, and floors above grade.

(b) Plates shall be large enough to completely close the hole around the pipe. Wall and ceiling plates shall have set screws; spring clips will not be acceptable.

(c) Where necessary to cover beads of fittings, special deep escutcheons shall be provided.

(11) Cutting and Repairing

(a) The work shall be careful laid out in advance. Cutting of structural works shall be done only with specific approval from the Engineer. Damage from the cutting shall be carefully repaired by skilled workmen of the trade involved.

(12) Invert Elevation

(a) The Private Party shall verify the proposed invert elevations prior to laying pipes.

(13) Termination of Water and Drainage Piping

(a) Water and drainage pipes extended to points 1.50 meters beyond the building structure shall be capped or plugged for future connection, or connection under other sections of these Specifications.

(b) If trenches are closed, or the pipes are otherwise covered before being connected to the utility systems, the locations of the end of each pipe shall be marked with a stake properly tagged or otherwise identified.

(14) Underground Pipes

(a) All steel pipes to be buried underground shall be externally coated in the mill of the fabricator. Material shall conform to AWWA C 203. Sequence of application shall be as follows:-

(i) Sandblast

(ii) Apply coat of plasticized coal tar primer.

(iii) Apply flood coat of hot plasticized coal tar enamel, 2.4 mm. minimum thicknesses.

(iv) Apply spiral wrap with 20 mil fiberglass.

(v) Apply flood coat of hot plasticized coat for enamel, 2.4 mm. minimum thicknesses.

(vi) Apply spiral wrap with 6.8 kg asbestos felt.

(vii) After the top coat has been cured at approximately 20°C for not less than 16 hours, the external protective coating shall be tested electrically using an approved holiday detector and shall be free of missed spots.

(b) Underground pipe supports attached to the building structure shall be made of stainless steel.

(c) Back fill and under-fill shall be made with sand.

(15) Flashing

Vent pipes shall be flashed and made watertight at the roof with 4-pound sheet lead. Flashings shall extend not less than 200 mm from the vent pipes in all directions and shall extend up the vent pipe not less than 150 mm at which point threaded standard cast-iron or malleable-iron recess roof couplings shall be installed to form counter-flashing or rain guards.

(16) Valve

(a) Shutoff gate valves shall be furnished and installed in each supply main where it enters the building. All valves used for pipe or equipment drains shall be of the too expensive, if possible, please change to gate valve type. All valves shall be installed in accessible locations or otherwise access panels shall be provided. No valve shall be installed with its stem below the horizontal. These valves shall be rated for 10 kg/cm2 working pressure or more.

(b) Furnish and install a trap on each fixture and each piece of equipment requiring connection to the sewer system, except fixtures or equipment having an integral trap or seal. Each trap shall be placed as close to the fixture as possible and no fixture shall be double-trapped. All traps installed in accessible locations shall have cleanout plugs or other approved means for cleaning. Slip joints in traps will be permitted only on the inlet side or in the trap seal.

(17) Water Pipe

(a) All pipes shall be installed with a pitch to drain. Where branches are connected to vertical risers, each branch shall drain back to its respective riser. Provide drain valves at all low points of the system to permit complete draining.

(b) Branches from service lines may be taken of the top, bottom or side of the main, using such cross over fittings as may be required by conditions.

(c) Unions shall not be concealed in walls or partitions nor covered with insulations.

3.5.3.2 Testing and commissioning

(1) Cold water piping shall be tested with water pressure of not less than specified or 1 ½ times the maximum working pressure, whichever is greater, at the lowest point in the system. Care shall be taken to avoid putting excessive pressure on safety devices, etc. These delicate control mechanisms shall be removed during the tests to prevent shock damage. The system shall be tested when water temperatures and average ambient temperatures are approximately equal and constant. Test pressure shall be maintained for not less than 30 minutes without an appreciable drop after the force pump has been disconnected.

(2) Piping may be tested a section at time in order to facilitate the construction.

(3) Leaks in screwed fittings shall be corrected by remaking the joints. Leaks in welded joints shall be cut out and rewelded. Caulking of leaks will not be permitted.

(4) After pressure tests have been made, the entire water-distribution system to be sterilized shall be thoroughly flushed with water until all entrained dirt and mud have been removed before introducing chlorinating material. The chlorinating material shall be either liquid chlorine or hypochlorite. The chlorinating material shall provide a dosage of not less than 50 PPM. and shall be introduced into the system in an approved manner. The treated water shall be retained in the pipe long enough to destroy all nonspore-forming bacteria. Except where a shorter period is approved, the retention time shall be at least 24 hours and shall produce not less than 10 PPM of chlorine at the extreme end of the system of the retention period. All valves in the system being sterilized shall be opened and closed several times during the contact period.

(5) The system shall then be flushed with clean water until the residual chlorine is reduced to less than 0.2 PPM. During the flushing period all valves and faucets shall be turned on and off several times.

3.6 HOT WATER SUPPLY PIPING WORK

3.6.1 General

3.6.1.1 General Requirement

(1) The Private Party shall furnish and install all piping work including all necessary parts as specified herein.

3.6.1.2 Standards and References

(1) The piping work shall comply with the following codes and standards.

(a)	ASTM B88	:	Seamless Copper Tube for Water, Gas and Sanitation
(b)	BS 2871 Part 1	:	Copper Tube for water, gas and Sanitation
(c)	ASTM C177	:	Steady State Heat Flux measurements and Thermal Transmission Properties by mean of the Guarded Hot Plate Apparatus
(d)	ASTM C534	:	Perform flexible elastomeric cellular thermal insulation in sheet and tubular form

(e)	BS 874 Part 2	:	Determining thermal insulating property part 2. Test for thermal conductivity and related properties
(f)	DIN 52615	:	Determination of water vapor (moisture) permeability of construction and insulation materials
(g)	ASTM D1056 Type 1	:	Flexible cellular materials-Sponge or Expanded Rubber
(h)	ASTM E96	:	Water Vapor Transmission of Materials
(i)	ASTM E84	:	Surface Burning Characteristic of Building Materials
(j)	ASTM D635	:	Rate of Burning and/or Extend and Time of Burning of Plastics in the Horizontal Position
(k)	UL 94	:	Flammability of Plastic Materials for Parts in Devices and Appliances

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

3.6.1.3 Submittals

(1) The Private Party shall submit all material, catalog, material lists and technical data request for approval before installation.

3.6.1.4 Warranty

(1) All part or the piping work shall be guaranteed by the Private Party at least 2 years after handover.

3.6.1.5 Delivery, Handling, Storage and Cleaning

(1) Pipes shall be delivered and stored with plugged ends. Ends shall be kept closed with temporary covers during erection. Before any pipe is installed, it shall be opened and pounded to remove any foreign substances, or swabbed, if necessary, for thorough cleaning.

(2) Pipes shall be stored on racks in a suitable warehouse or cover to avoid rusting. If necessary, carbon steel pipes shall be coated with anodic rust converter or red lead primer.

(3) During the course of installation, the Private Party shall take every precaution to prevent any debris from being left in the pipes. He shall be responsible for any damage that may occur.

(4) Immediately after erection, exposed threads at all fittings shall be painted with zinc-chromate paint, and after welding each joint shall be wire-brushed and then painted with zinc-chromate paint.

(5) Before start-up, all piping systems shall be thoroughly flushed with water until it runs clear.

(6) Fixtures and equipment shall be lightly covered and protected against damage. At the completion of the work, fixtures, materials and equipment shall be thoroughly cleaned and delivered in a satisfactory condition.

3.6.2 Material

3.6.2.1 Description

(1) The hot water piping shall be the types or models, which are suitable for the working fluid in the system.

(2) The rated working pressure of the hot water piping system as specified for the working fluid shall be at least 1.5 times of the actual working pressure, but not less than 1,034 kPa (150 PSIG.).

3.6.2.2 Component

(1) Hot Water Pipe

(a) Hot water pipes shall be of the hard drawn copper tube type L, conforming to ASTM B88 or BS 2871.

(b) Copper tube fitting shall be wrought copper weld fitting (solder type) or solder to thread and shall be rated at 10 kg/cm^2.

(c) Bronze unions or flanges shall be used at the connections of steel and copper tube.

(2) Insulation of Hot Water Pipes

(a) The insulation shall be closed cell structure, elastomeric thermal insulation, moisture and vapor barriers, self-extinguishing with fire and low smoke density while burning.

(b) Properties of Insulation shall be as the following:

(i) Thermal conductivity shall not be more than 0.038 W/m./K (0.26 BTU/Hr/ft^2/ $^\circ$F/Inch.) at 24°C (75°F) by test method of either ASTM C177, BS 874

(ii) Water absorption shall not be more than 5 percentage by weight method of ASTM C534 or ASTM D1056 Type 1

(iii) Water vapor permeability shall be <0.10 perm-in in compliance to ASTM E96

(iv) Moisture Resistance shall be ≥5,000 μ in compliance to DIN 52615

(v) Flammability shall be 25 in compliance to ASTM E84 or Class V-0 in compliance to UL94 or surface spread of flame of Class 1 in compliance to BS476 Part 7. Smoke density shall be 50 in compliance to ASTM E84

(vi) Density shall be 48-96 kg/cu.m. (3-6 lbs/cu.ft.)

(vii) Service temperature shall be -20°C to 105°C (-4°F to 220°F)

(c) The insulation shall be preformed tube or rolled sheet. The thickness of pipe insulation shall be as follows:-

Pipe Diameter (mm.)	Insulation Thickness (mm.)
50 (2”) and smaller	40 (1 1.2”)
65 (2 ½”) to 150 (6")	50 (2”)
Over 150 (6")	50 (2”)

(3) Fittings for Galvanized Steel Pipes

Fittings for galvanized steel pipes shall be galvanized malleable cast-iron, conforming to ASTM A120-73 or TISI 249-1997.

3.6.3 Execution

3.6.3.1 Installation

(1) General piping installation

(a) All piping shall be installed parallel to, or at right angles with, the building walls and partitions. A pitch in the direction of flow and drain shall be not less than 1: 500. Branches from water mains shall be taken in a manner that facilities venting and draining. Reductions in bore shall be formed eccentrically to facilitate venting, except on vertical pipes where concentric reduction may be used.

(b) All water piping shall be installed in such a way that all circuits can be completely drained off and all air pockets in the water circuits shall be suitably vented.

(c) Clearance between pipe works and equipment or machinery shall be adequately provided to facilitate maintenance. Overhead clearance shall be at least 600 mm. over access ways, and where possible the projection of valve stems into access ways shall be avoided. Pipe works and pumps shall be so arranged that the removal for maintenance of the equipment can be carried out with minimum dismantling. Provision of all pipe fittings and accessories necessary for the efficient functioning of the various systems shall be included.

(d) Pipes shall be installed in continuous lengths as long as possible. Except where required to be connected to fitting outlets or headers, they shall be joined by welding, solvent welding, screwing or soldering as approved or indicated in these Specifications.

(e) The equipment or piping shall be installed so that it will not provide a cross connection or interconnection between a distributing supply for drinking or domestic purposes and a polluted supply such as a drainage system or a soil or waste pipe that will permit or make possible the backflow of sewage, polluted water or waste into the water supply system. Where crossing a sewer or waste line is inevitable, the water line shall be not less than 0.30 meters above the sewer line, which shall be cast-iron soil pipe for not less than 30 meters on each side of the crossing.

(f) All pipes shall be installed in an appropriate manner to present a neat and orderly appearance, using fittings for all changes of direction, and arranging pipe run parallel to or at right angles with structural members of the building, to provide utmost head-room and to clear lights and other obstructions. In general, suspended pipes shall be installed as closely as possible to the overhead structure.

(2) Workmanship

(a) All pipes shall be cut accurately to measurements established at the site, and shall be worked into place without springing or forcing. Piping shall be installed so that it may expand and contract freely without injury to itself or other work. Steel and wrought-iron pipe shall be cut with pipe cutters and threaded with sharp, clean dies. All cut sections shall be reamed to remove all burrs and to restore the pipe to full diameter. All changes in size shall be made with reducing fitting. Pipe bends and bushings are prohibited.

(3) Location of Device

(a) All valves, cleanouts, equipment, accessories, and devices shall be so located that they are accessible for repair and replacement.

(4) Connection to Equipments

(a) Connections to coils, pumps and other equipment shall be made in such a manner that undue strains between pipes and equipment are eliminated. Unions and/or flanges shall be used to facilitate the removal of the equipment.

(5) Expansion and Contraction

(a) The piping systems shall be installed so that there will be no damage due to expansion and contraction during operation.

(b) Packless type expansion connectors shall be used where the expansion and contraction of the pipe is excessive or cannot be compensated by expansion loops or offsets.

(6) Differential Settlement

(a) The piping systems shall be installed so that there will be no damage due to differential settlement of the pipe supports after installation. The problems shall be avoided by providing flexible connections.

(7) Sleeves

(a) Vertical pipes passing through floors shall be provided with sleeves of black steel pipes. Sleeves shall be of a proper length to pass through the entire floor construction and shall terminate 50 mm. above the finished floor level.

(b) Horizontal pipes passing through walls and partitions shall be provided with full thickness sleeves made of standard weight black steel pipes.

(c) Sleeves shall be large enough to leave not less than 12.5 mm. clearances around the pipe and covering insulation, if there is any. Sleeves shall be set in place where the walls and partitions are built.

(d) Sleeves in concrete work shall be flanged at the bottom or provided with temporary centering caps and securely nailed or screwed to formwork before the concrete is poured.

(e) Provide chromium-plated escutcheon, where exposed pipes pass through walls or floors.

(f) When sleeves are installed through a fire wall, the clearance between sleeves and pipes shall be filled with fire-resistant material. The fire rating of the fire-resistant material shall be at least equivalent to that of the fire wall.

(g) When pipes pass through waterproof walls, water retaining rings with approved type of sealant shall be applied.

(8) Pipe Joints

(a) Joint for Threaded Pipe

Joints for threaded pipes shall be made with an approved Teflon tape or graphite compound applied to the male threads only. Threads exposed after joints are made up shall be mopped with compound. Threads shall be of the cleanout, tapered threads with the ends being reamed before installation.

(b) Joint for Flanged Pipe

(i) Flanged joints shall be installed at all valves larger than 50 mm. and at other places where necessary.

(ii) Jointing flanges shall be truly parallel to each other so that bolts are used only to tighten joints, rather than correct alignment. Flanges shall be chosen to suit the maximum working pressure of the system. Bolts, nuts and washers shall be cadmium-plated steel.

(c) Joint for Copper Pipe

Joints shall be done with silver-soldering. The copper tube surface shall be cleaned prior to and after the soldering to prevent oxidation.

(d) Welded Pipe Joint

(i) The edges of the pipe to be welded shall be machine-beveled wherever possible. Gas cuts shall be true and free of all burnt metal. Before welding, the surfaces shall be thoroughly cleaned and degreased. The welding technique shall be such as to ensure penetration to the full thickness of the pipe wall and through fusion of the deposited metal with the parent metal. During welding the ends of the pipes shall be held firmly together by suitable lugs, welded-on-bridge pieces or adequate tack welding. Special care shall be taken to prevent formation of welded obstructions and lodgment of welding residue inside the pipes. Cracks, pinholes, excessive under-cutting, etc. shall be removed and the joints rewelded. Welding materials and workmanship shall be in accordance with AWS.

(ii) Welders must be entirely competent and may be required to perform site tests. Should the Engineer not be satisfied, the welder must be replaced. The Engineer reserves the right to order the cutout for inspection of up to 1 percent of the total number of welds. In the event of any inspected welds being, in the Engineer opinion, unsatisfactory he reserves the right to order the removal of further welds which in his opinion indicate faulty workmanship. Welds removed for inspection shall be reinstalled.

(iii) Either the electric arc or the oxy-acetylene welding method may be used. Welding rods or electrodes shall have such composition that the welds produced by them shall have the same analysis as the parent metal and shall be of an approved type and brand.

(9) Hanger and Supports

(a) All pipes shall be securely supported. Horizontal piping shall be supported by adjustable clevis type hangers with solid rods securely attached to the building structure. Where several pipes run in a parallel fashion, trapeze hangers may be used in lieu of separate hangers. All hangers shall have turnbuckles or other approved means of adjustment. Where pipes, such as those from individual toilet rooms to main stacks, are not low enough to permit the use of turnbuckles, other means of adjustment shall be used. Chains, straps, perforated bars, or wire hangers will not be accepted. All hangers and supports shall be hot-dip galvanized. The maximum distances between hangers and supports for horizontally mounted and vertically mounted pipes shall be as indicated below.

(b) For all pipes where the hanger clips bear directly on pipes and for hangers of dissimilar metals, suitable apparition with a layer of felt shall be provided to prevent corrosion. Hangers on structural steel is absolutely prohibited, unless with the express approval from the Engineer.

(c) Anchors for steel pipes shall be welded directly to the pipe wall and securely bolted to the building structure. Anchors for copper and PVC pipes shall be of the split ring type. Hangers in the plant room shall be supported on springs.

(d) Supporting brackets shall be fastened to concrete by means of inserts or expansion bolts, to brickwork by means of expansion bolts, and to hollow masonry by means of toggle bolts. Two fixings per bracket shall be provided as follows:-

Nominal Pipe Size (mm.)	**Fixing Size (mm.)**
Up to 65 (2 ½")	6.4 (1/4")
80 (3") to 150 (6")	9.5 (3/8")
200 (8") to 300 (12")	12.7 (1/2")

(e) All hangers and steel supports shall be zinc coating.

(f) The thickness of coating shall be not less than 300 grammas of zinc per square meter (1 oz per sq.ft.) of the surface covered. Underground pipe support and hanger shall be all stainless steel.

(g) Schedule of Pipe Supports as shown in the following table.

SCHEDULE OF PIPE SUPPORTS							
Nominal Pipe Size (mm.)	Hanger Rod Min. Size (mm.)	Maximum Interval (m.)					
		Steel Pipe		PVC Pipe		Copper Pipe	
		Horiz.	Vert.	Horiz.	Vert.	Horiz.	Vert.
15 (1/2")	9	2.0	2.4	0.9	1.2	1.5	1.8
20 (3/4")	9	2.4	3.0	1.0	1.2	1.8	2.4
25 (1")	9	2.4	3.0	1.0	1.2	1.8	2.4
32 (1 ¼")	9	2.4	3.0	1.2	1.8	2.0	3.0
40 (1 ½")	9	3.0	3.6	1.3	1.8	2.4	3.0
50 (2")	9	3.0	3.6	1.5	1.8	2.4	3.6

SCHEDULE OF PIPE SUPPORTS							
Nominal Pipe Size (mm.)	Hanger Rod Min. Size (mm.)	Maximum Interval (m.)					
		Steel Pipe		PVC Pipe		Copper Pipe	
		Horiz.	Vert.	Horiz.	Vert.	Horiz.	Vert.
65 (2 ½”)	12	3.0	4.5	1.8	2.4	3.0	3.6
80 (3”)	12	3.6	4.5	2.0	2.4	3.0	3.6
80 (3”)	15	4.0	4.5	2.4	2.4	3.6	3.6
100 (4”)	15	4.8	4.5	2.4	3.0		
125 (5”)	22	4.8	4.5	2.4	3.0		
150 (6”)	22	6.0	4.8	3.0	3.6		
200 (8”)	22	6.0	4.8				
250 (10”)	22	6.0	4.8				
300 (12”)	22	6.0	4.8				

(10) Floor, Wall and Ceiling Plate

Furnish and install plates on all entry and exit openings for all exposed pipes passing through finished walls, finished partitions, finished ceilings, and floors above grade. Plates shall be large enough to completely close the hole around the pipe. Wall and ceiling plates shall have set screws; spring clips will not be acceptable. Where necessary to cover beads of fittings, special deep escutcheons shall be provided.

(11) Cutting and Repairing

The work shall be careful laid out in advance. Cutting of structural works shall be done only with specific approval from the Engineer. Damage from the cutting shall be carefully repaired by skilled workmen of the trade involved.

(12) Invert Elevation

The Private Party shall verify the proposed invert elevations prior to laying pipes.

(13) Termination of Water and Drainage Piping

Water and drainage pipes extended to points 1.50 meters beyond the building structure shall be capped or plugged for future connection, or connection under other sections of these Specifications. If trenches are closed, or the pipes are otherwise covered before being connected to the utility systems, the locations of the end of each pipe shall be marked with a stake properly tagged or otherwise identified.

(14) Flashing

Vent pipes shall be flashed and made watertight at the roof with 4-pound sheet lead. Flashings shall extend not less than 200 mm from the vent pipes in all directions and shall extend up the vent pipe not less than 150 mm at which point threaded standard cast-iron or malleable-iron recess roof couplings shall be installed to form counter-flashing or rain guards.

(15) Valve

(a) Location and Type

Shutoff gate valves shall be furnished and installed in each supply main where it enters the building. All valves used for pipe or equipment drains shall be of the too expensive, if possible, please change to gate valve type. All valves shall be installed in accessible locations or otherwise access panels shall be provided. No valve shall be installed with its stem below the horizontal. These valves shall be rated for 10 kg/cm^2 working pressure or more.

(b) Trap

Furnish and install a trap on each fixture and each piece of equipment requiring connection to the sewer system, except fixtures or equipment having an integral trap or seal. Each trap shall be placed as close to the fixture as possible and no fixture shall be double-trapped. All traps installed in accessible locations shall have cleanout plugs or other approved means for cleaning. Slip joints in traps will be permitted only on the inlet side or in the trap seal.

(16) Water Pipe

(a) All pipes shall be installed with a pitch to drain. Where branches are connected to vertical risers, each branch shall drain back to its respective riser. Provide drain valves at all low points of the system to permit complete draining.

(b) Branches from service lines may be taken of the top, bottom or side of the main, using such cross over fittings as may be required by conditions.

(c) Unions shall not be concealed in walls or partitions nor covered with insulations.

3.6.3.2 Testing and commissioning

(1) Hot water piping shall be tested with water pressure of not less than specified or 1 ½ times the maximum working pressure, whichever is greater, at the lowest point in the system. Care shall be taken to avoid putting excessive pressure on safety devices, etc. These delicate control mechanisms shall be removed during the tests to prevent shock damage. The system shall be tested when water temperatures and average ambient temperatures are approximately equal and constant. Test pressure shall be maintained for not less than 30 minutes without an appreciable drop after the force pump has been disconnected.

(2) Piping may be tested a section at time in order to facilitate the construction.

(3) Leaks in screwed fittings shall be corrected by remaking the joints. Leaks in welded joints shall be cut out and rewelded. Caulking of leaks will not be permitted.

(4) After pressure tests have been made, the entire water-distribution system to be sterilized shall be thoroughly flushed with water until all entrained dirt and mud have been removed before introducing chlorinating material. The chlorinating material shall be either liquid chlorine or hypochlorite. The chlorinating material shall provide a dosage of not less than 50 PPM. and shall be introduced into the system in an approved manner. The treated water shall be retained in the pipe long enough to destroy all nonspore-forming

bacteria. Except where a shorter period is approved, the retention time shall be at least 24 hours and shall produce not less than 10 PPM of chlorine at the extreme end of the system of the retention period. All valves in the system being sterilized shall be opened and closed several times during the contact period.

(5) The system shall then be flushed with clean water until the residual chlorine is reduced to less than 0.2 PPM. During the flushing period all valves and faucets shall be turned on and off several times.

3.7 SANITARY PIPING WORK

3.7.1 General

3.7.1.1 General Requirement

(1) The Private Party shall furnish and install all piping work including all necessary parts as specified herein.

3.7.1.2 Standards and References

(1) Piping and accessories shall comply with the following codes and standards.

(a)	ASTM A74	:	Standard specification for cast iron soil pipe and fittings
(b)	ASTM D2239	:	Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR)
(c)	TIS 982-1990	:	High-density polyethylene pipes for drinking water services
(d)	TIS 277-1989	:	Galvanized steel pipes
(e)	TIS 533-1987	:	Cast iron spigot and socket soil, waste and ventilating pipes
(f)	TIS 604-1986	:	Cast iron pipe fittings
(g)	TIS 249-1997	:	Malleable cast iron threaded pipe fittings
(h)	ASTM A120	:	Welded Steel Pipes Zinc-Coated, Threaded and Coupled (GTC)

(i) ASTM D2241 : Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)

(j) ASTM D1785 : Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

3.7.1.3 Submittals

(1) The Private Party shall submit all material, catalog, material lists and technical data request for approval before installation.

3.7.1.4 Warranty

(1) All part or the piping work shall be guaranteed by the Private Party at least 2 years after handover.

3.7.1.5 Delivery, Handling, Storage and Cleaning

(1) Pipes shall be delivered and stored with plugged ends. Ends shall be kept closed with temporary covers during erection. Before any pipe is installed, it shall be opened and pounded to remove any foreign substances, or swabbed, if necessary, for thorough cleaning.

(2) Pipes shall be stored on racks in a suitable warehouse or cover to avoid rusting. If necessary, carbon steel pipes shall be coated with anodic rust converter or red lead primer.

(3) During the course of installation, the Private Party shall take every precaution to prevent any debris from being left in the pipes. He shall be responsible for any damage that may occur.

(4) Immediately after erection, exposed threads at all fittings shall be painted with zinc-chromate paint, and after welding each joint shall be wire-brushed and then painted with zinc-chromate paint.

(5) Before start-up, all piping systems shall be thoroughly flushed with water until it runs clear.

(6) Fixtures and equipment shall be lightly covered and protected against damage. At the completion of the work, fixtures, materials and equipment shall be thoroughly cleaned and delivered in a satisfactory condition.

3.7.2 Material

3.7.2.1 Description

(1) The sanitary piping shall be the types or models, which are suitable for the working fluid in the system.

(2) The rated working pressure of the sanitary piping system as specified for the working fluid shall be at least 1.5 times of the actual working pressure.

(3) The sanitary piping accessories which have positive from discharge of pump or negative pressure from suction of pump shall have pressure rating same of the pump.

3.7.2.2 Component

(1) Soil, Waste and Drain Pipes

(a) Soil and waste pipe inside building shall be cast-iron pipe (No-Hub type) class extra heavy conforming to ASTM 74-42, TIS 533-1987

(b) Soil and waste pipe outside building shall be High Density Polyethylene (HDPE) pipe PN6.3 conforming to ASTM D2239, TIS 982-1990

(2) Vent Pipe

(a) Vent Pipe inside building shall be Galvanized Steel Pipe Class B conforming to TIS 277-1989

(b) Underground vent pipe shall be High Density Polyethylene (HDPE) pipe PN 6.3 conforming to ASTMD 2239, TIS 982-1990

(3) Waste Pipes from Drainage Pumps

(a) Pipe from drainage pump shall be galvanized steel pipes medium weight conforming to Thai Industrial Standard, TIS 277-1989, Class B.

(4) Fittings for Galvanized Steel Pipes

(a) Fittings for galvanized steel pipes shall be galvanized malleable cast-iron, conforming to ASTM A120-73 or TISI 249-1997.

(5) Fittings for Cast-Iron Pipes

(a) Fitting for cast-iron pipes shall be cast-iron waste and drain pipe fittings, conforming to ASTM A74-42. or TIS 604-1986

(6) Fittings for Polyvinyl Chloride Pipes

(a) Fittings for polyvinyl chloride pipes shall be rigid, unplasticized polyvinyl chloride (PVC) as designated in ASTM D2241, ASTM D1785, Schedule 40.

(7) Fittings for High Density Polyethylene (HDPE)

(a) Fitting for HDPE pipes shall be high density polyethylene as requirement or recommendation of manufacture.

3.7.3 Execution

3.7.3.1 Installation

(1) General piping installation

(a) All piping shall be installed parallel to, or at right angles with, the building walls and partitions. A pitch in the direction of flow and drain shall be not less than 1: 500. Branches from water mains shall be taken in a manner that facilities venting and draining. Reductions in bore shall be formed eccentrically to facilitate venting, except on vertical pipes where concentric reduction may be used.

(b) All water piping shall be installed in such a way that all circuits can be completely drained off and all air pockets in the water circuits shall be suitably vented.

(c) Clearance between pipe works and equipment or machinery shall be adequately provided to facilitate maintenance. Overhead clearance shall be at least 600 mm. over access ways, and where possible the projection of valve stems into access ways shall be avoided. Pipe works and pumps shall be so arranged that the removal for maintenance of the equipment can be carried out with minimum dismantling. Provision of all pipe fittings and accessories necessary for the efficient functioning of the various systems shall be included.

(d) Pipes shall be installed in continuous lengths as long as possible. Except where required to be connected to fitting outlets or headers, they shall be joined by welding, solvent welding, screwing or soldering as approved or indicated in these Specifications.

(e) The equipment or piping shall be installed so that it will not provide a cross connection or interconnection between a distributing supply for drinking or domestic purposes and a polluted supply such as a drainage system or a soil or waste pipe that will permit or make possible the backflow of sewage, polluted water or waste into the water supply system. Where crossing a sewer or waste line is inevitable, the water line shall be not less than 0.30 meters above the sewer line, which shall be cast-iron soil pipe for not less than 30 meters on each side of the crossing.

(f) All pipes shall be installed in an appropriate manner to present a neat and orderly appearance, using fittings for all changes of direction, and arranging pipe run parallel to or at right angles with structural members of the building, to provide utmost head-room and to clear lights and other obstructions. In general, suspended pipes shall be installed as closely as possible to the overhead structure.

(2) Workmanship

(a) All pipes shall be cut accurately to measurements established at the site, and shall be worked into place without springing or forcing.

(b) Piping shall be installed so that it may expand and contract freely without injury to itself or other work. Steel and wrought-iron pipe shall be cut with pipe cutters and threaded with sharp, clean dies. All cut sections shall be reamed to remove all burrs and to restore the pipe to full diameter. All changes in size shall be made with reducing fitting.

(c) Pipe bends and bushings are prohibited.

(3) Location of Device

(a) All valves, cleanouts, equipment, accessories, and devices shall be so located that they are accessible for repair and replacement.

(4) Connection to Equipments

(a) Connections to coils, pumps and other equipment shall be made in such a manner that undue strains between pipes and equipment are eliminated.

(b) Unions and/or flanges shall be used to facilitate the removal of the equipment.

(5) Expansion and Contraction

(a) The piping systems shall be installed so that there will be no damage due to expansion and contraction during operation.

(b) Packless type expansion connectors shall be used where the expansion and contraction of the pipe is excessive or cannot be compensated by expansion loops or offsets.

(6) Differential Settlement

(a) The piping systems shall be installed so that there will be no damage due to differential settlement of the pipe supports after installation. The problems could be avoided by providing flexible connections.

(7) Sleeves

(a) Vertical pipes passing through floors shall be provided with sleeves of black steel pipes. Sleeves shall be of a proper length to pass through the entire floor construction and shall terminate 50 mm. above the finished floor level.

(b) Horizontal pipes passing through walls and partitions shall be provided with full thickness sleeves made of standard weight black steel pipes.

(c) Sleeves shall be large enough to leave not less than 12.5 mm. clearances around the pipe and covering insulation, if there is any. Sleeves shall be set in place where the walls and partitions are built.

(d) Sleeves in concrete work shall be flanged at the bottom or provided with temporary centering caps and securely nailed or screwed to formwork before the concrete is poured.

(e) Provide chromium-plated escutcheon, where exposed pipes pass through walls or floors.

(f) When sleeves are installed through a fire wall, the clearance between sleeves and pipes shall be filled with fire-resistant material. The fire rating of the fire-resistant material shall be at least equivalent to that of the fire wall.

(g) When pipes pass through waterproof walls, water retaining rings with approved type of sealant shall be applied.

(8) Pipe Joints

(a) Joint for Cast-Iron Pipe

(i) Joints for cast-iron pipes, hubs or bell-and spigots shall be made by tightly packing and caulking oakum gaskets or braided or twisted jute into the annular space between a spigot and hub or a bell to within 1 1/2 inches (3.75 cm) of the face of the hub or the bell, and filling the remaining space with molten lead at one pouring. The lead shall then be caulked to produce a watertight joint without overstraining the hub or the bell. When finished, the lead shall be flush with face of the hub or the bell.

(ii) Joints for No-Hub cast-iron pipes shall be made by Neoprene rubber sleeve conforming to ASTM D-15 and couplings with 304 stainless steel shaft and nut screw. Pipes and joints shall be plain ends.

(iii) When cast-iron pipe is used for pump suction or discharge pipe, the joint shall be flanged joint.

(b) Joint for Threaded Pipe

(i) Joints for threaded pipes shall be made with an approved Teflon tape or graphite compound applied to the male threads only. Threads exposed after joints are made up shall be mopped with compound.

(ii) Threads shall be of the cleanout, tapered threads with the ends being reamed before installation.

(c) Joint for Flanged Pipe

(i) Flanged joints shall be installed at all valves larger than 50 mm. and at other places where necessary.

(ii) Jointing flanges shall be truly parallel to each other so that bolts are used only to tighten joints, rather than correct alignment. Flanges shall be chosen to suit the maximum working pressure of the system. Bolts, nuts and washers shall be cadmium-plated steel.

(d) Joint for PVC Pipes

(i) All PVC pipe works shall be strictly installed in accordance with manufacturer's instructions. It shall be joined with a push fit, sealed rubber rings (or equal and approved jointing method), to allow for expansion. They shall be fixed with PVC or PVC-coated wrought iron brackets at distances specified in the next clause.

(e) Welded Pipe Joint

(i) The edges of the pipe to be welded shall be machine-beveled wherever possible. Gas cuts shall be true and free of all burnt metal. Before welding, the surfaces shall be thoroughly cleaned and degreased. The welding technique shall be such as to ensure penetration to the full thickness of the pipe wall and through fusion of the deposited metal with the parent metal. During welding the ends of the pipes shall be held firmly together by suitable lugs, welded-on-bridge pieces or adequate tack welding. Special care shall be taken to prevent formation of welded obstructions and lodgment of welding residue inside the pipes. Cracks, pinholes, excessive under-cutting, etc. shall be removed and the joints rewelded. Welding materials and workmanship shall be in accordance with AWS.

(ii) Welders must be entirely competent and may be required to perform site tests. Should the Engineer's Representative not be satisfied, the welder must be replaced. The Engineer's Representative reserves the right to order the cutout for inspection of up to 1 percent of the total number of welds. In the event of any inspected welds being, in the Engineer's Representative opinion, unsatisfactory he reserves the right to order the removal of further welds which in his opinion indicate faulty workmanship. Welds removed for inspection shall be reinstalled.

(iii) Either the electric arc or the oxy-acetylene welding method may be used. Welding rods or electrodes shall have such composition that the welds produced by them shall have the same analysis as the parent metal and shall be of an approved type and brand.

(9) Hanger and Supports

(a) All pipes shall be securely supported. Horizontal piping shall be supported by adjustable clevis type hangers with solid rods securely attached to the building structure. Where several pipes run in a parallel fashion, trapeze hangers may be used in lieu of separate hangers. All hangers shall have turnbuckles or other approved means of adjustment. Where pipes, such as those from individual toilet rooms to main stacks, are not low enough to permit the use of turnbuckles, other means of adjustment shall be used. Chains, straps, perforated bars, or wire hangers will not be accepted. All hangers and supports shall be hot-dip galvanized. The maximum distances between hangers and supports for horizontally mounted and vertically mounted pipes shall be as indicated below.

(b) For all pipes where the hanger clips bear directly on pipes and for hangers of dissimilar metals, suitable apparition with a layer of felt shall be provided to prevent corrosion. Hangers on structural steel is absolutely prohibited, unless with the express approval from the Engineer's Representative.

(c) Anchors for steel pipes shall be welded directly to the pipe wall and securely bolted to the building structure. Anchors for copper and PVC pipes shall be of the split ring type. Hangers in the plant room shall be supported on springs.

(d) Supporting brackets shall be fastened to concrete by means of inserts or expansion bolts, to brickwork by means of expansion bolts, and to hollow masonry by means of toggle bolts. Two fixings per bracket shall be provided as follows:-

Nominal Pipe Size (mm.)	Fixing Size (mm.)
Up to 65 (2 ½”)	6.4 (1/4”)
80 (3”) to 150 (6”)	9.5 (3/8”)
200 (8”) to 300 (12”)	12.7 (1/2”)

(e) All hangers and steel supports shall be zinc coating.

(f) The thickness of coating shall be not less than 300 grammas of zinc per square meter (1 oz per sq.ft.) of the surface covered. Underground pipe support and hanger shall be all stainless steel.

(g) Schedule of Pipe Supports as shown in the following table:

SCHEDULE OF PIPE SUPPORTS							
Nominal Pipe Size (mm.)	Hanger Rod Min. Size (mm.)	Maximum Interval (m.)					
		Steel Pipe		PVC Pipe		Copper Pipe	
		Horiz.	Vert.	Horiz.	Vert.	Horiz.	Vert.
15 (1/2”)	9	2.0	2.4	0.9	1.2	1.5	1.8
20 (3/4”)	9	2.4	3.0	1.0	1.2	1.8	2.4
25 (1”)	9	2.4	3.0	1.0	1.2	1.8	2.4
32 (1 ¼”)	9	2.4	3.0	1.2	1.8	2.0	3.0
40 (1 ½”)	9	3.0	3.6	1.3	1.8	2.4	3.0
50 (2”)	9	3.0	3.6	1.5	1.8	2.4	3.6
65 (2 ½”)	12	3.0	4.5	1.8	2.4	3.0	3.6
80 (3”)	12	3.6	4.5	2.0	2.4	3.0	3.6
80 (3”)	15	4.0	4.5	2.4	2.4	3.6	3.6

SCHEDULE OF PIPE SUPPORTS							
Nominal Pipe Size (mm.)	Hanger Rod Min. Size (mm.)	Maximum Interval (m.)					
		Steel Pipe		PVC Pipe		Copper Pipe	
		Horiz.	Vert.	Horiz.	Vert.	Horiz.	Vert.
100 (4”)	15	4.8	4.5	2.4	3.0		
125 (5”)	22	4.8	4.5	2.4	3.0		
150 (6”)	22	6.0	4.8	3.0	3.6		
200 (8”)	22	6.0	4.8				
250 (10”)	22	6.0	4.8				
300 (12”)	22	6.0	4.8				

(h) Cast-Iron Pipe : Horizontal maximum shall be 3.00 m, with a least on hanger for each pipe section. Hangers should be located adjacent to joints, changes in direction and branch connection.

(10) Floor, Wall and Ceiling Plate

(a) Furnish and install plates on all entry and exit openings for all exposed pipes passing through finished walls, finished partitions, finished ceilings, and floors above grade. Plates shall be large enough to completely close the hole around the pipe.

(b) Wall and ceiling plates shall have set screws; spring clips will not be acceptable. Where necessary to cover beads of fittings, special deep escutcheons shall be provided.

(11) Cutting and Repairing

(a) The work shall be careful laid out in advance. Cutting of structural works shall be done only with specific approval from the Engineer’s Representative.

(b) Damage from the cutting shall be carefully repaired by skilled workmen of the trade involved.

(12) Invert Elevation

(a) The Private Party shall verify the proposed invert elevations prior to laying pipes.

(13) Termination of Water and Drainage Piping

(a) Water and drainage pipes extended to points 1.50 meters beyond the building structure shall be capped or plugged for future connection, or connection under other sections of these Specifications.

(b) If trenches are closed, or the pipes are otherwise covered before being connected to the utility systems, the locations of the end of each pipe shall be marked with a stake properly tagged or otherwise identified.

(14) Underground Pipes

All steel pipes to be buried underground shall be externally coated in the mill of the fabricator. Material shall conform to AWWA C 203. Sequence of application shall be as follows:-

(a) Sandblast

(b) Apply coat of plasticized coal tar primer.

(c) Apply flood coat of hot plasticized coal tar enamel, 2.4 mm. minimum thicknesses.

(d) Apply spiral wrap with 20 mil fiberglass.

(e) Apply flood coat of hot plasticized coat for enamel, 2.4 mm. minimum thicknesses.

(f) Apply spiral wrap with 6.8 kg asbestos felt.

(g) After the top coat has been cured at approximately 20°C for not less than 16 hours, the external protective coating shall be tested electrically using an approved holiday detector and shall be free of missed spots.

(h) Underground pipe supports attached to the building structure shall be made of stainless steel.

(i) Back fill and under-fill shall be made with sand.

(15) Flashing

(a) Vent pipes shall be flashed and made watertight at the roof with 4-pound sheet lead. Flashings shall extend not less than 200 mm from the vent pipes in all directions and shall extend up the vent pipe not less than 150 mm at which point threaded standard cast-iron or malleable-iron recess roof couplings shall be installed to form counter-flashing or rain guards.

(16) Valve

(a) Shutoff gate valves shall be furnished and installed in each supply main where it enters the building. All valves used for pipe or equipment drains shall be gate valve type. All valves shall be installed in accessible locations or otherwise access panels shall be provided. No valve shall be installed with its stem below the horizontal. These valves shall be rated for 10 kg/cm2 working pressure or more.

(b) Furnish and install a trap on each fixture and each piece of equipment requiring connection to the sewer system, except fixtures or equipment having an integral trap or seal. Each trap shall be placed as close to the fixture as possible and no fixture shall be double-trapped. All traps installed in accessible locations shall have cleanout plugs or other approved means for cleaning. Slip joints in traps will be permitted only on the inlet side or in the trap seal.

(17) Floor Cleanout

(a) Floor cleanouts shall have an iron body ferrule with raised head brass plug or with spanner wrench sockets.

(18) Drain

(a) Outside Floor Drain

Floor drains shall be of the cast-iron type and be provided with trap, chromium-plated brass inlet grating and round removable cast-brass strainer. They shall, furthermore, be threaded or caulked connection.

(b) Floor and Area Drain

Drains and backwater valves installed in connection with waterproofed floors shall be equipped with bolted-type clamping devices. Floor drain for mechanical room shall be tunnel floor drain.

(19) Grease Trap

(a) Grease trap shall be of the sizes and dimensions indicated typical details. They shall be constructed of complete sets from manufacture.

(20) Soil, Waste and Drain Piping

(a) Slope

Horizontal lines shall be installed with a minimum slope in the direction of flow of 2 cm per meter (1:50) for pipes of 80 mm and smaller sizes and with 1 cm. per meter (1:100) for larger pipe sizes.

(b) Fitting

All changes in pipe sizes shall be made with reducing fittings or recessed reducers while changes in direction shall be made with "Y" fittings, combination Y and 1/8 bends, long sweep 1/4 bends, 1/6, 1/8, and 1/16 bends. Sanitary "Tee" branches may be used when the direction of flow is from a horizontal line to a vertical line, and short sweep 1/4 bends may be used on the discharge from a water closet. Union connections shall be made with tucker or hub drainage fittings.

(21) Vent Line

(a) Slope

Horizontal lines shall be pitched to drain back to the drainage system without forming traps, using fittings as required.

(b) Arrangement

Except where otherwise indicated, main vertical soil and waste stacks shall be extended full size to and above the roof line as vents. Where practicable, two or more vent pipes shall be connected together and extended as one pipe through the roof. Vertical vent pipes shall be connected together and extended as one pipe through the roof. Vertical vent pipes may be connected into on main vent riser above vented fixtures. Unless indicated otherwise, sanitary piping shall form circuit or loop vents with no dead ends or inverted siphons. Circuit or loop vent lines shall be connected at a height of not less than 300 mm. above the highest fixture served. Horizontal waste lines receiving the discharge from two or more fixtures shall be provided with end vents unless separate venting of fixtures is shown. Where a vent is taken from a horizontal drain line, the vent connection shall be made above the centerline of the drain, either on the top or at an angle of not more than 45 degrees from the vertical. The bottoms of vent stacks shall be so connected that any dirt or scale from the inside of the stacks will be flushed out through the soil or waste piping. All vent stacks shall be extended to a minimum of 300 mm above the roof and be equipped with a flashing fitting and special waterproof hood.

11.7.3.2 Testing and commissioning

Operating test run shall be provided from manufacturer.

3.8 STORM DRAIN PIPING WORK

3.8.1 General

3.8.1.1 General Requirement

(1) The Private Party shall furnish and install all piping work including all necessary parts as specified herein.

3.8.1.2 Standards and References

(1) The Piping work and accessories shall comply with the following codes and standards.

(a) ASTM A74 : Standard specification for cast iron soil pipe and fittings

(b) ASTM D2239 : Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR)

(c) TIS 982-1990 : High-density polyethylene pipes for drinking water services

(d) TIS 277-1989 : Galvanized steel pipes

(e) TIS 533-1987 : Cast iron spigot and socket soil, waste and ventilating pipes

(f) TIS 604-1986 : Cast iron pipe fittings

(g) TIS 249-1997 : Malleable cast iron threaded pipe fittings

(h) ASTM A120 : Welded Steel Pipes Zinc-Coated, Threaded and Coupled (GTC)

(i) ASTM D2241 : Standard Specification for Poly Vinyl Chloride (PVC) Pressure-Rated Pipe (SDR Series)

(j) ASTM D1785 : Standard Specification for Poly Vinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

3.8.1.3 Submittals

(1) The Private Party shall submit all material, catalog, material lists and technical data request for approval before installation.

3.8.1.4 Warranty

(1) All part or the piping work shall be guaranteed by the Private Party at least 2 years after handover.

3.8.1.5 Delivery, Handling, Storage and Cleaning

(1) Pipes shall be delivered and stored with plugged ends. Ends shall be kept closed with temporary covers during erection. Before any pipe is installed, it shall be opened and pounded to remove any foreign substances, or swabbed, if necessary, for thorough cleaning.

(2) Pipes shall be stored on racks in a suitable warehouse or cover to avoid rusting. If necessary, carbon steel pipes shall be coated with anodic rust converter or red lead primer.

(3) During the course of installation, the Private Party shall take every precaution to prevent any debris from being left in the pipes. He shall be responsible for any damage that may occur.

(4) Immediately after erection, exposed threads at all fittings shall be painted with zinc-chromate paint, and after welding each joint shall be wire-brushed and then painted with zinc-chromate paint.

(5) Before start-up, all piping systems shall be thoroughly flushed with water until it runs clear.

(6) Fixtures and equipment shall be lightly covered and protected against damage. At the completion of the work, fixtures, materials and equipment shall be thoroughly cleaned and delivered in a satisfactory condition.

3.8.2 Material

3.8.2.1 Description

(1) The storm drain piping shall be the types or models, which are suitable for the working fluid in the system.

(2) The rated working pressure of the storm drain piping system as specified for the working fluid shall be at least 1.5 times of the actual working pressure.

(3) The storm drain piping accessories which have positive from discharge of pump or negative pressure from suction of pump shall have pressure rating same of the pump.

3.8.2.2 Component

(1) Rain Water Pipes

(a) Rain water pipes inside building shall be galvanized steel pipes medium weight, conforming to TIS 277-2521, Class B.

(b) Underground rain water pipe shall be High Density Polyethylene (HDPE) pipe PN 6.3 conforming to ASTMD 2239, TIS 982-1990

(2) Storm Drain Pipe

Storm drain pipe shall be Reinforced Concrete pipe, Tongue & Groove Joint Type, conforming to TISI 128-2528 Class 3 or Local Standard which equal.

(3) Fittings for Galvanized Steel Pipes

Fittings for galvanized steel pipes shall be galvanized malleable cast-iron, conforming to ASTM A120-73 or TISI 249-1997.

(4) Fittings for High Density Polyethylene (HDPE)

Fitting for HDPE pipes shall be high density polyethylene as requirement or recommendation of manufacture.

3.8.3 Execution

3.8.3.1 Installation

(1) General piping installation

(a) All piping shall be installed parallel to, or at right angles with, the building walls and partitions. A pitch in the direction of flow and drain shall be not less than 1: 500. Branches from water mains shall be taken in a manner that facilities venting and draining. Reductions in bore shall be formed eccentrically to facilitate venting, except on vertical pipes where concentric reduction may be used.

(b) All water piping shall be installed in such a way that all circuits can be completely drained off and all air pockets in the water circuits shall be suitably vented.

(c) Clearance between pipe works and equipment or machinery shall be adequately provided to facilitate maintenance. Overhead clearance shall be at least 600 mm. over access ways, and where possible the projection of valve stems into access ways shall be avoided. Pipe works and pumps shall be so arranged that the removal for maintenance of the equipment can be carried out with minimum dismantling. Provision of all pipe fittings and accessories necessary for the efficient functioning of the various systems shall be included.

(d) Pipes shall be installed in continuous lengths as long as possible. Except where required to be connected to fitting outlets or headers, they shall be joined by welding, solvent welding, screwing or soldering as approved or indicated in these Specifications.

(e) The equipment or piping shall be installed so that it will not provide a cross connection or interconnection between a distributing supply for drinking or domestic purposes and a polluted supply such as a drainage system or a soil or waste pipe that will permit or make possible the backflow of sewage, polluted water or waste into the water supply system. Where crossing a sewer or waste line is inevitable, the water line shall be not less than 0.30 meters above the sewer line, which shall be cast-iron soil pipe for not less than 30 meters on each side of the crossing.

(f) All pipes shall be installed in an appropriate manner to present a neat and orderly appearance, using fittings for all changes of direction, and arranging pipe run parallel to or at right angles with structural members of the building, to provide utmost head-room and to clear lights and other obstructions. In general, suspended pipes shall be installed as closely as possible to the overhead structure.

(2) Workmanship

All pipes shall be cut accurately to measurements established at the site, and shall be worked into place without springing or forcing. Piping shall be installed so that it may expand and contract freely without injury to itself or other work. Steel and wrought-iron pipe shall be cut with pipe cutters and threaded with sharp, clean dies. All cut sections shall be reamed to remove all burrs and to restore the pipe to full diameter. All changes in size shall be made with reducing fitting. Pipe bends and bushings are prohibited.

(3) Location of Device

All valves, cleanouts, equipment, accessories, and devices shall be so located that they are accessible for repair and replacement.

(4) Connection to Equipments

Connections to coils, pumps and other equipment shall be made in such a manner that undue strains between pipes and equipment are eliminated. Unions and/or flanges shall be used to facilitate the removal of the equipment.

(5) Expansion and Contraction

(a) The piping systems shall be installed so that there will be no damage due to expansion and contraction during operation.

(b) Packless type expansion connectors shall be used where the expansion and contraction of the pipe is excessive or cannot be compensated by expansion loops or offsets.

(6) Differential Settlement

The piping systems shall be installed so that there will be no damage due to differential settlement of the pipe supports after installation. The problems shall be avoided by providing flexible connections.

(7) Sleeves

(a) Vertical pipes passing through floors shall be provided with sleeves of black steel pipes. Sleeves shall be of a proper length to pass through the entire floor construction and shall terminate 50 mm. above the finished floor level.

(b) Horizontal pipes passing through walls and partitions shall be provided with full thickness sleeves made of standard weight black steel pipes.

(c) Sleeves shall be large enough to leave not less than 12.5 mm. clearances around the pipe and covering insulation, if there is any. Sleeves shall be set in place where the walls and partitions are built.

(d) Sleeves in concrete work shall be flanged at the bottom or provided with temporary centering caps and securely nailed or screwed to formwork before the concrete is poured.

(e) Provide chromium-plated escutcheon, where exposed pipes pass through walls or floors.

(f) When sleeves are installed through a fire wall, the clearance between sleeves and pipes shall be filled with fire-resistant material. The fire rating of the fire-resistant material shall be at least equivalent to that of the fire wall.

(g) When pipes pass through waterproof walls, water retaining rings with approved type of sealant shall be applied.

(8) Pipe Joints

(a) Joint for Threaded Pipe

Joints for threaded pipes shall be made with an approved Teflon tape or graphite compound applied to the male threads only. Threads exposed after joints are made up shall be mopped with compound. Threads shall be of the cleanout, tapered threads with the ends being reamed before installation.

(b) Joint for Flanged Pipe

(i) Flanged joints shall be installed at all valves larger than 50 mm. and at other places where necessary.

(ii) Jointing flanges shall be truly parallel to each other so that bolts are used only to tighten joints, rather than correct alignment. Flanges shall be chosen to suit the maximum working pressure of the system. Bolts, nuts and washers shall be cadmium-plated steel.

(c) Joint for PVC Pipes

All PVC pipe works shall be strictly installed in accordance with manufacturer's instructions. It shall be joined with a push fit, sealed rubber rings (or equal and approved jointing method), to allow for expansion. They shall be fixed with PVC or PVC-coated wrought iron brackets at distances specified in the next clause.

(d) Welded Pipe Joint

(i) The edges of the pipe to be welded shall be machine-beveled wherever possible. Gas cuts shall be true and free of all burnt metal. Before welding, the surfaces shall be thoroughly cleaned and degreased. The welding technique shall be such as to ensure penetration to the full thickness of the pipe wall and through fusion of the deposited metal with the parent metal. During welding the ends of the pipes shall be held firmly together by suitable lugs, welded-on-bridge pieces or adequate tack welding. Special care shall be taken to prevent formation of welded obstructions and lodgment of welding residue inside the pipes. Cracks, pinholes, excessive under-cutting, etc. shall be removed and the joints rewelded. Welding materials and workmanship shall be in accordance with AWS.

(ii) Welders must be entirely competent and may be required to perform site tests. Should the Engineer's Representative not be satisfied, the welder must be replaced. The Engineer's Representative reserves the right to order the cutout for inspection of up to 1 percent of the total number of welds. In the event of any inspected welds being, in the Engineer's Representative opinion, unsatisfactory he reserves the right to order the removal of further welds which in his opinion indicate faulty workmanship. Welds removed for inspection shall be reinstalled.

(iii) Either the electric arc or the oxy-acetylene welding method may be used. Welding rods or electrodes shall have such composition that the welds produced by them shall have the same analysis as the parent metal and shall be of an approved type and brand.

(9) Hanger and Supports

(a) All pipes shall be securely supported. Horizontal piping shall be supported by adjustable clevis type hangers with solid rods securely attached to the building structure. Where several pipes run in a parallel fashion, trapeze hangers may be used in lieu of separate hangers. All hangers shall have turnbuckles or other approved means of adjustment. Where pipes, such as those from individual toilet rooms to main stacks, are not low enough to permit the use of turnbuckles, other means of adjustment shall be used. Chains, straps, perforated bars, or wire hangers will not be accepted. All hangers and supports shall be hot-dip galvanized. The maximum distances between hangers and supports for horizontally mounted and vertically mounted pipes shall be as indicated below.

(b) For all pipes where the hanger clips bear directly on pipes and for hangers of dissimilar metals, suitable apparition with a layer of felt shall be provided to prevent corrosion. Hangers on structural steel is absolutely prohibited, unless with the express approval from the Engineer's Representative.

(c) Anchors for steel pipes shall be welded directly to the pipe wall and securely bolted to the building structure. Anchors for copper and PVC pipes shall be of the split ring type. Hangers in the plant room shall be supported on springs.

(d) Supporting brackets shall be fastened to concrete by means of inserts or expansion bolts, to brickwork by means of expansion bolts, and to hollow masonry by means of toggle bolts. Two fixings per bracket shall be provided as follows:-

Nominal Pipe Size (mm.)	Fixing Size (mm.)
Up to 65 (2 ½")	6.4 (1/4")
80 (3") to 150 (6")	9.5 (3/8")
200 (8") to 300 (12")	12.7 (1/2")

(e) All hangers and steel supports shall be zinc coating.

(f) The thickness of coating shall be not less than 300 grammas of zinc per square meter (1 oz per sq.ft.) of the surface covered. Underground pipe support and hanger shall be all stainless steel.

(g) Schedule of Pipe Supports as shown in the following table:

SCHEDULE OF PIPE SUPPORTS							
Nominal Pipe Size (mm.)	Hanger Rod Min. Size (mm.)	Maximum Interval (m.)					
		Steel Pipe		PVC Pipe		Copper Pipe	
		Horiz.	Vert.	Horiz.	Vert.	Horiz.	Vert.
15 (1/2”)	9	2.0	2.4	0.9	1.2	1.5	1.8
20 (3/4”)	9	2.4	3.0	1.0	1.2	1.8	2.4
25 (1”)	9	2.4	3.0	1.0	1.2	1.8	2.4
32 (1 ¼”)	9	2.4	3.0	1.2	1.8	2.0	3.0
40 (1 ½”)	9	3.0	3.6	1.3	1.8	2.4	3.0
50 (2”)	9	3.0	3.6	1.5	1.8	2.4	3.6
65 (2 ½”)	12	3.0	4.5	1.8	2.4	3.0	3.6
80 (3”)	12	3.6	4.5	2.0	2.4	3.0	3.6
80 (3”)	15	4.0	4.5	2.4	2.4	3.6	3.6
100 (4”)	15	4.8	4.5	2.4	3.0		
125 (5”)	22	4.8	4.5	2.4	3.0		
150 (6”)	22	6.0	4.8	3.0	3.6		
200 (8”)	22	6.0	4.8				
250 (10”)	22	6.0	4.8				
300 (12”)	22	6.0	4.8				

(10) Floor, Wall and Ceiling Plate

Furnish and install plates on all entry and exit openings for all exposed pipes passing through finished walls, finished partitions, finished ceilings, and floors above grade. Plates shall be large enough to completely close the hole around the pipe. Wall and ceiling plates shall have set screws; spring clips will not be acceptable. Where necessary to cover beads of fittings, special deep escutcheons shall be provided.

(11) Cutting and Repairing

The work shall be careful laid out in advance. Cutting of structural works shall be done only with specific approval from the Engineer’s Representative.

Damage from the cutting shall be carefully repaired by skilled workmen of the trade involved.

(12) Invert Elevation

The Private Party shall verify the proposed invert elevations prior to laying pipes.

(13) Termination of Water and Drainage Piping

Water and drainage pipes extended to points 1.50 meters beyond the building structure shall be capped or plugged for future connection, or connection under other sections of these Specifications. If trenches are closed, or the pipes are otherwise covered before being connected to the utility systems, the locations of the end of each pipe shall be marked with a stake properly tagged or otherwise identified.

(14) Underground Pipes

All steel pipes to be buried underground shall be externally coated in the mill of the fabricator. Material shall conform to AWWA C 203. Sequence of application shall be as follows:-

(a) Sandblast

(b) Apply coat of plasticized coal tar primer.

(c) Apply flood coat of hot plasticized coal tar enamel, 2.4 mm. minimum thicknesses.

(d) Apply spiral wrap with 20 mil fiberglass.

(e) Apply flood coat of hot plasticized coat for enamel, 2.4 mm. minimum thicknesses.

(f) Apply spiral wrap with 6.8 kg asbestos felt.

(g) After the top coat has been cured at approximately 20°C for not less than 16 hours, the external protective coating shall be tested electrically using an approved holiday detector and shall be free of missed spots.

Underground pipe supports attached to the building structure shall be made of stainless steel.

Back fill and under-fill shall be made with sand.

(15) Flashing

Vent pipes shall be flashed and made watertight at the roof with 4-pound sheet lead. Flashings shall extend not less than 200 mm from the vent pipes in all directions and shall extend up the vent pipe not less than 150 mm at which point threaded standard cast-iron or malleable-iron recess roof couplings shall be installed to form counter-flashing or rain guards.

(16) Valve

(a) Shutoff gate valves shall be furnished and installed in each supply main where it enters the building. All valves used for pipe or equipment drains shall be of the too expensive, if possible, please change to gate valve type. All valves shall be installed in accessible locations or otherwise access panels shall be provided. No valve shall be installed with its stem below the horizontal. These valves shall be rated for 10 kg/cm2 working pressure or more.

(b) Furnish and install a trap on each fixture and each piece of equipment requiring connection to the sewer system, except fixtures or equipment having an integral trap or seal. Each trap shall be placed as close to the fixture as possible and no fixture shall be double-trapped. All traps installed in accessible locations shall have cleanout plugs or other approved means for cleaning. Slip joints in traps will be permitted only on the inlet side or in the trap seal.

(17) Floor Cleanout

Floor cleanouts shall have an iron body ferrule with raised head brass plug or with spanner wrench sockets.

(18) Drain

(a) Outside Floor Drain

Floor drains shall be of the cast-iron type and be provided with trap, chromium-plated brass inlet grating and round removable cast-brass strainer. They shall, furthermore, be threaded or caulked connection.

(b) Floor and Area Drain

Drains and backwater valves installed in connection with waterproofed floors shall be equipped with bolted-type clamping devices. Floor drain for mechanical room shall be tunnel floor drain.

(c) Roof Drain

Roof drains shall be of the heavy pattern cast-iron type, with an integral flange and satisfactory device for clamping or otherwise securing the roofing and flashing to make a watertight connection. Openings in the strainer shall have a combined area equal to twice the area of the drain outlet. The outlet shall be equipped with necessary parts for proper connection to threaded pipes of the same size as downspout.

3.8.3.2 Testing and Commissioning

Operating test run shall be provided from manufacturer.

3.9 VALVE AND ACCESSORIES

3.9.1 General

3.9.1.1 General Requirement

(1) Shut-off valves shall be furnished as necessary for a satisfactory operation of all apparatus.

(2) Valves of the same type shall be supplied by the same manufacturer.

3.9.1.2 Standards and References

(1) The valves and accessories shall comply with the following codes and standards.

(a)	ASTM A53/A53M-04a	:	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
(b)	ASTM B75-02	:	Standard Specification for Seamless Copper Tube.
(c)	TIS 277-2521	:	Steel Pipes
(d)	ASME/ANSI B16	:	Standards of Pipes and Fittings
(e)	ASME Section VIII	:	Pressure Vessels; Boiler and Pressure Vessel Codes
(f)	ANSI/NEMA 250	:	Enclosure for Electrical Equipment
(g)	ASTM A216	:	Carbon steel castings, suitable for fusion welding for high temperature service.

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

3.9.1.3 Submittals

(1) The Private Party shall submit all valves and accessories performance selection, catalog, material lists and technical data for approval before installation.

3.9.1.4 Warranty

(1) All parts of valves and accessories shall be guaranteed by the manufacturer and/or by the Private Party for at least 2 years after handover.

3.9.2 Material

3.9.2.1 Description

(1) The valves shall be the types or models which are suitable for the working fluid in the system. The rated working pressure of the valve as specified for the working fluid shall be at least 1.5 times of the actual working pressure, but not less than 1,034 kPa (150 PSIG.).

(2) The diameter of hand wheels for valves shall be of a suitable size so as to allow tight closure by hand with the application of reasonable force so that neither additional leverage nor damage shall be imposed upon the stem, seat and disc. Where indicated or required, for inaccessible overhead valves, chain-operated hand wheels including rustproof chain and chain guide shall be provide.

3.9.2.2 Component

(1) Gate Valves

(a) Valves of size up to 50 mm. (2”) shall be bronze where appropriate, with threaded ends, solid wedges and non-rising stems.

(b) Valves of sizes 65 mm. (2 ½”) and larger shall be cast-iron or ductile iron where appropriate, with flanged ends, solid wedges and rising stems.

(2) Globe Valves

(a) Valves of sizes up to 50 mm. (2”) shall be bronze where appropriate with threaded ends and union bonnets.

(b) Valves of 65 mm. (2 ½”) and larger shall be cast-iron or ductile iron, bronze-trimmed where appropriate, with flanged ends.

(3) Swing-Check Valves

(a) Valves shall be of the swing type suitable for the horizontal or vertical operation with a two-piece hinge and accessible disc cover.

(b) Valves of sizes up to 50 mm. (2”) shall be bronze where appropriate, with threaded ends and full area Y pattern bodies.

(c) Valves of sizes 65 mm. (2 ½”) and larger shall be cast-iron, swing pattern and bronze-trimmed where appropriate, with flanged ends.

(4) Lift-Check Valves

(a) Lift-check valves or silent-type check valves shall be installed at the location where noise and water hammer would cause a problem. The valves shall be of a spring closed type.

(b) Seats, discs, and springs shall be bronze or stainless steel, whichever is appropriate.

(c) Valves of sizes up to 50 mm. (2”) shall be bronze where appropriate, with threaded ends.

(d) Valves of sizes 65 mm. (2 ½”) and larger shall be cast-iron where appropriate, with flanged ends.

(5) Butterfly Valves

(a) A butterfly valve can be used instead of a gate valve if its size is over 100 mm. (4”); it shall have flange bolt centering holes for easy installation and be drilled to suit precisely the piping flange (Full lug type).

(b) The body shall be cast-iron or ductile iron with aluminum-bronze disc where appropriate of sufficient rigidity and strength to resist distortion. The stem shall be through-shaft design to provide high strength and positive disc control.

(c) Compound rubber seat rings shall have excellent elasticity as well as wear resistance to ensure positive water shut-off under the designed working pressure. Moulded-in "O" rings shall provide positive flange sealing to eliminate need for gaskets. All rubber parts shall be of the type suitable for the specified working fluid.

(d) Lever-operated valves shall be used for sizes up to 150 mm. (6”). Gear-operated valves shall be used for sizes larger than 150 mm. (6”). Position indicators shall be provided to indicate valve disc position.

(6) Ball Valves

(a) Valves shall be ball pattern of the square head type with stainless steel ball conforming to AISI 304.

(b) Valves of sizes up to 50 mm. (2”) shall be bronze with threaded ends conforming to ASTM B62 and for valves of sizes larger than 50 mm. (2”) Valve body shall be carbon steel conforming to ASTM A216.

(7) Float Valve

(a) The valve shall be hydraulically operated, diaphragm-actuated globe or angle pattern valve. Operation of the main valve shall be controlled by a two-level remote float control.

(b) The body shall be cast-iron with flanged ends and shall have a pressure rating of 1,206 kPa. (175 psi [class 125]). A stilling well must be provided around the float to protection against water surface turbulence.

(8) Pressure Regulating Valve

(a) The valve shall automatically reduce a higher inlet pressure to a steady lower downstream pressure regardless of changing flow rate and/or varying inlet pressure. This valve is an accurate pilot-operated regulator, capable of holding downstream pressure to a pre-determined delivery pressure.

(b) The body of main valve shall be cast-iron with screwed or flanged ends and have a pressure rating of 1,206 kPa. (175 psi [class 125]).

(9) Pressure Reducing Valve

(a) The Pressure Reducing Valve is a hydraulically operated, single seated globe valve controlled by a direct acting spring and diaphragm pilot valve. It available in globe or angle body.

(b) The main valve is operated by the downstream pressure passing through the pilot system. It will reduce a high pressure of upstream to a predetermined lower pressure of downstream.

(i) Pressure ratings : 1,034 kPa. (150 PSI.)

(ii) Pressure adjust ranges : 170 to 550 kPa. (25 to 80 PSI.)

(iii) Materials :

- Main Valve : Cast iron
- Body & Bonnet : Cast iron
- Seat : Stainless Steel
- Stem : Stainless Steel
- Diaphragm : Reinforced Synthetic Rubber

(10) Pressure Relief Valve

(a) Pressure relief valve shall be installed at the pump discharge line to provide protection against high surge when pump is shut down. It shall be of globe patters diaphragm valve with hydraulically-operated, pilot-controlled and modulating type.

(b) The body of main valve shall be cast-iron with screw or flanged ends of pressure rating class 125.

(11) Water Hammer Arrestors (Air Rechargeable)

(a) This water hammer arrestor shall be installed at discharged pipe of water pump.

(b) It contains only one moving part; a spherical piston which floats inside the surge copper chamber, built in valve and gauge assembly simplified charging and recharging procedure.

(12) Flexible Connections

(a) Where it is considered necessary, and only with the Engineer's Representative approval, flexible connections at inlets and outlets of pumps shall be of stainless steel flexible connector.

(b) The flexible connectors shall be designed for excellent vibration and noise protection. Isolated tension members shall be provided to prevent excessive elongation.

(c) Flexible connections shall be suitable for the specified working fluid and specified working pressure and temperature.

(13) Expansion Joints (For Steam and Hot Water System)

(a) Packless construction externally pressurized guide expansion connectors shall be used where the expansion and contraction of the pipe is excessive or cannot be compensated by expansion loops or offsets.

(b) Anchors and pipe guides shall be provided and installed at the recommended locations. All expansion connectors shall have flanged ends with working pressure corresponding with the piping system

(14) Strainers

(a) Water strainers shall be of the Y type. Strainers of 50 mm. (2”) and smaller shall have bronze or iron bodies with screwed connections while 65 mm. (2 ½”) strainers and larger shall have iron bodies and flanged connections. They shall have the same rating as the piping system.

(b) Water strainers shall comply with the requirements of the ASTM Standards.

(c) Screens shall be stainless steel with perforations as follows:-

Strainer Size (mm.)	Screens Perforation (mm.)
20 (3/4”) to 50 (2”) inclusive	0.76
65 (2 ½”) to 150 (6”) inclusive	1.52
200 (8”) to 300 (12”) inclusive	3.05
Over 300 (12”)	6.10

(d) The free area of each screen shall be not less than three times the area of the strainer inlet pipe. Strainers of 65 mm. and larger shall be provided with 15 mm. valve drains.

(15) Air Vents and Drains

(a) Manual air vents shall be furnished as required for purging air or other gases from the water circuit during filling-up. The outlet shall be piped to the nearest drain.

(b) Automatic air vents, conforming to ASA standards, shall be furnished at the top of main water risers, supply and return pipes.

(c) A shut-off valve shall be provided at the inlet of each automatic air vent. The outlet shall be piped to the nearest drain.

(d) A plug-type drain cock shall be provided at all low points of pipe work systems. Drains shall be installed to ensure easy access and convenience for maintenance and removal of all piping, valves, fittings and equipment without undue spillage.

(e) Drainage facilities shall be provided and suitable sized to drain expeditiously the entire system and equipment involved.

(16) Thermometers

(a) Thermometers shall be of the adjustable-angle glass tube-type in a 230 mm. (9”) case, accurate to +1/2 C. The scale range shall be suitable for the specified working fluid temperature and shall be of 230 mm. (9") scale case, dual scale with F and C.

(b) Thermometers and socket wells shall be selected, and shall be subjected to Engineer’s Representative approval, with their stem length suitable for the size of pipes where they are to be installed.

(17) Pressure Gauges

(a) Pressure gauges shall be of the bourbon type, stainless steel casing, round type of 100 mm. dial and scale range of approximately 150 per cent of the normal operation. Pressure readings shall be in dual scale with psi and kg/cm2.

(b) A needle valve and snubber with working pressure corresponding with the piping system shall be provided for each pressure gauge.

(c) Pressure gauges, subjected to corrosive liquid, shall be of the chemical type with diaphragm liquid separator.

(18) Flow Measuring Equipment

(a) Flow measuring devices shall be annular flow measuring stations and a portable meter set shall be provided, complete with master chart for direct conversion of meter readings to m3/h, carrying case, two 4 m. hoses, equalizer manifold, check seal, installation and operating instructions. Meters shall become the property of MRTA

(b) Meters shall be factory assembled eagle eye flow meters or equal approved.

(c) Each station shall be complete with safety shut-off valves and quick connect coupling connections.

(d) Annular elements shall be made of stainless steel where appropriate and rated to 20 kg/cm2 at 66 C.

(e) Each station shall be tagged by means of brass tag, attached with a chain, that indicates the station number, meter setting and m3/h.

(f) Welding sockets shall be supplied by the flow meter manufacturer.

(g) Where required, the flow meters shall be equipped with a built-in electronic totallizer, a square-root extractor, and a power unit for the transmitter to the central control console.

(19) Water Meters

(a) Water meters shall be of the displacement and accumulative reading type, conforming to the Metropolitan Water Works Authority Standard with working pressure corresponding with the piping system.

3.9.3 Execution

3.9.3.1 Installation

(1) Installation shall be followed instruction manual from manufacturer.

3.9.3.2 Testing and commissioning

(1) Operating test run shall be as recommended by the manufacturer.

3.10 ELECTRICAL AND CONTROL WORKS

3.10.1 General

3.10.1.1 General Requirement

(1) This part of the Specification describes all electrical equipment and installations including connections thereof for the aforementioned system.

(2) The Private Party shall furnish and install all equipment and accessories for the electrical and control works as per scope of installation being finalized at the detail design stage which shall be approved by the Engineer's Representative.

(3) In general, the building services electrical works will be responsible for providing and installing power cabling onto Motor Control Centers (MCCs) and/or power distribution boards that are in scope of the mechanical works, and power cabling complete with terminal devices such as disconnecting switches, enclosed circuit breakers, junction boxes, etc. The mechanical works will be the provision and installation of equipment ongoing from the electrical works thereof.

(4) All items of a similar nature shall be products of one manufacturer.

(5) All equipment, wiring methods and the installation shall conform to the latest applicable standards as specified in this specification.

3.10.1.2 Standard and Reference

The electrical and control works shall comply with the following codes and standards.

(1)	IEC 60227-1	:	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V - Part 1: General requirements
(2)	IEC 60228	:	Conductors of insulated cables
(3)	IEC 60502-1	:	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1.2 kV) up to 30 kV (Um = 36 kV) - Part 1: Cables for rated voltages of 1 kV (Um = 1.2 kV) and 3 kV (Um = 3.6 kV)

(4)	IEC 60332-1-1	:	Tests on electric and optical fibre cables under fire conditions - Part 1-1: Test for vertical flame propagation for a single insulated wire or cable – Apparatus
(5)	IEC 60332-3-10	:	Tests on electric and optical fibre cables under fire conditions - Part 3-10: Test for vertical flame spread of vertically-mounted bunched wires or cables – Apparatus
(6)	IEC 61034-2	:	Measurement of smoke density of cables burning under defined conditions - Part 2: Test procedure and requirements
(7)	IEC 60754-2	:	Test on gases evolved during combustion of materials from cables – Part 2: Determination of acidity (by pH measurement) and conductivity
(8)	TIS 11-2553	:	Thai Industrial Standard for PVC insulated copper cables
(9)	ANSI/NEMA FB 1	:	Fittings, Cast Metal Boxes and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
(10)	ASTM A123/A123M	:	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
(11)	ASTM D1248	:	Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
(12)	NEMA ANSI C80.1	:	Electrical rigid steel conduit (RSC)
(13)	NEMA ANSI C80.3	:	Steel electrical metallic tubing (EMT)
(14)	NEMA ANSI C80.6	:	Electrical intermediate metal conduit (IMC)
(15)	IEC 61439-1	:	Low-voltage switchgear and controlgear assemblies - Part 1: General rules
(16)	IEC 61439-2	:	Low-voltage switchgear and controlgear assemblies - Part 2: Power switchgear and controlgear assemblies
(17)	IEC 60947-1	:	Low-voltage switchgear and controlgear - Part 1: General rules
(18)	IEC 60947-2	:	Low-voltage switchgear and controlgear - Part 2: Circuit-breakers

(19)	IEC 60947-4-1	:	Low-voltage switchgear and controlgear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters
(20)	IEC 60947-7	:	Low-voltage switchgear and controlgear - Part 7: Ancillary equipment
(21)	IEC 60269-1	:	Low-voltage fuses - Part 1: General requirements
(22)	IEC 60269-4	:	Low-voltage fuses - Part 4: Supplementary requirements for fuse-links for the protection of semiconductor devices
(23)	IEC 61869-1	:	Instrument transformers - Part 1: General requirements
(24)	IEC 61869-2	:	Instrument transformers - Part 2: Additional requirements for current transformers
(25)	IEC 61326	:	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements
(26)	IEC 61010-1	:	Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements
(27)	IEC 62053-21	:	Electricity metering equipment (a.c.) - Particular requirements - Part 21: Static meters for active energy (classes 1 and 2)
(28)	IEC 60529	:	Degree of protection provided by enclosures (IP Code)
(29)	NFPA 130	:	Standard for Fixed Guideway Transit and Passenger Rail Systems
(30)	NFPA 70	:	National Electrical Code
(31)	EIT 2001-56	:	Thai Electrical Code 2013
(32)	MEA	:	Metropolitan Electricity Authority

In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

The standards and codes as mentioned above can be equivalent by another standards and codes, if it equal or better than the standards and codes mentioned when comply between two codes.

3.10.1.3 Submittals

(1) The material lists and technical data, Working Drawings, details of all material and equipment installations, and catalog shall be submitted to the Engineer's Representative for approval before purchasing and installation.

3.10.1.4 Quality Assurance

(1) The equipment manufacturer shall be ISO 9001 certified.

3.10.1.5 Warranty

(1) All parts of the electrical and control works shall be guaranteed by the Private Party at least two (2) years after handover.

3.10.2 Materials

3.10.2.1 Description

(1) The provision and installation of the equipment shall be based on the following electrical system:

(a) Rated Voltage : 415-Y/240V

(b) System Voltage : 380-Y/220V

(c) Rated Frequency : 50 Hz.

(d) Earthing System : TN-S (separate neutral and protective conductors throughout the system)

(2) All electrical conductors such as busbars, cables, wires, terminals, etc. shall be color-coded in compliance with EIT 2001-56 std. as follows:

(a) Phase A (R) : Brown

(2) Phase B (S) : Black

(3) Phase C (T) : Gray

(4) Neutral : Light Blue

(5) Ground : Green or Green-with-Yellow strip

(6) Large wires and cables and shall be color-coded with suitable heat shrinkable sleeves as the specified color.

(7) Busbars shall be color-coded with standard paint as the specified color.

3.10.2.2 Component

(1) Earthing (or Grounding) & Bonding

(a) The equipment grounding system shall be designed and installed such that all metallic, enclosures, raceway, junction boxes, outlet boxes, cabinets, machine frames, portable equipment, and other conductive items in close proximity with electrical circuits operate continuously at ground potential.

(b) The equipment grounding system shall provide a low impedance path for possible ground fault currents. The system shall consist of a separate green insulated equipment grounding conductor for each feeder and each branch circuit. The required grounding conductor shall be installed in the common conduit with the related phase and/or neutral conductors. Each electrical expansion fitting shall be provided with an external flexible braided ground strap securely bonded on each end of the fitting. The required equipment grounding conductors shall be sized in accordance with NEC - Table 250.122 or/and EIT 2001-56 Section 4 or other approved equivalent.

(c) Unless otherwise specified, the grounding connectors shall be of a type specifically manufactured for grounding purposes, made of copper alloy and assembled with high strength silicon bronze hardware. Where grounding or bonding conductors connect to structural cables, connections shall be made with mechanical devices; welded connections shall not be made at these points. All mechanical connections shall be completely encapsulated in non-hardening, conductive epoxy. The epoxy shall be applicable for wet locations or for ambient temperatures of 10 °C - 55 °C.

(d) Jumper material shall be flexible braided tinned-copper strap.

(e) Grounding of all pumps and other machines shall be done by means of separate green insulated equipment grounding conductor for each feeder or each branch circuit.

(2) Motor Control Centers (MCC)

(a) General Requirement

This provision covers the design and construction of motor control center of floor or wall mounting type. The equipment shall comply with the requirement in applicable standards of IEC as stipulated, or other standards as approved equivalent (or better).

(b) Electrical Characteristic

The electrical characteristic of the equipment shall be as follows:

(i) Rates voltage : 415V/240V

(ii) System Wiring : 3-Phase, 4-Wire with 33% Earth (ground)

(iii) Rated Frequency : 50 Hz.

(iv) Rated Current : to be specified at the detailed design stage.

(v) Rated Interrupting Capacity : to be specified at the detailed design stage.

(I_{CU} and I_{CS} in kA_{rms})

(vi) Insulation Class : 600V (Minimum)

(vii) Degree of protection : IP 31 (for Indoor), IP 55 (for Outdoor)

(c) The Construction of Motor Control Center

(i) Motor control center shall consist of two or more vertical sections bolted together to form a totally enclosed rigid construction. The vertical section shall be made of sheet steel (minimum thickness of 2 mm.). Each vertical section shall consist of three compartments viz. busbar, cable, terminal and control unit compartment which each compartment shall be separated by the standard steel sheet barrier. The motor control center shall be designed to permit easy addition and removal in the future.

(ii) Each control unit compartment shall be the combination of starter, circuit breaker and other accessories for each motor. The unit shall be completely enclosed and isolated from all other units. Unit side plates shall be permanently attached. Each unit shall have a single door mounted on removable hidden pin hinges. Each door shall be provided with a removable panel suitable for mounting push button, selector or switch and pilot lamp.

(iii) Efficient ventilation opening shall be provided on the panel. The opening shall be screened so as to be insect-proof.

(iv) Each panel shall undergo a treatment of degreasing and derusting by electro-galvanized or other equivalent method for anti-rust and shall be coated by an oven-baked enamel paint finished.

(v) All doors shall be provided with dust-protection gaskets of neoprene or any other approved material. All doors shall be equipped with locks operated by keys.

(vi) Plastic nameplate with engraved letters of at least 3 mm. thick shall be placed at ever circuit breaker and starter indicating their uses.

(vii) Mimic bus diagram shall be applied for each motor control center.

(viii) Uniform height and depth shall be adopted for the cubicles.

(d) Busbars and Busbar Holders

(i) The Busbars shall be 98% copper and shall be mechanically braced to withstand the maximum symmetrical short-circuit current rating of the main circuit breaker. The busbars shall have sufficient cross sectional area to continuously conduct rated full load current, as shown on the approved single line diagram, for operation in 35°C ambient temperature and for limit temperature rise within the requirements of IEC 61439-2. The current carrying capacity of the busbars shall be of the bare busbars rating conformed to IEC 61439-2.

(ii) Neutral and Ground busbar shall be equipped through the entire length of the cubicle.

(iii) A ground busbar sizing shall be not less than 33% of phase bus size.

(iv) All bolted bus jointed shall be silver plated or tin plated, and all joints shall be securely tightened to Manufacturer's standards for each size of hardware. Bolted, Nuts and Washers for buses connection shall be high tension class and the contact point between buses and terminal pad shall be electrical compound painted.

(v) Busbar holders shall be of fiber-glass reinforced polyester (FRP) type or Epoxy-resin (flame-proof material) or better. The calculation sheets and technical data, showing the minimum spacing between the busbar holders for withstand the maximum force caused by short circuit current, shall be submitted for approval.

(vi) Each busbar shall have colour identification conforming to the colour coding as stipulated.

(e) Moulded Case Circuit Breaker (MCCB)

(i) In general, all circuit breakers installed in the MCC shall be moulded case circuit breakers (MCCB) complying with IEC 60947-1 and IEC 60947-2 standard.

(ii) The MCCB shall be manually operated, quick–make, quick–break and trip-free for over-current and short circuit current, and have a common trip on all multi-pole breakers with internal tie mechanism. Drives shall be toggle operating mechanism, operated by trip-free system and shall have clearly indication whether the circuit breaker is "ON", "OFF" or "TRIP".

(iii) All MCCB shall be capable of being installed the additional devices such as shunt trip, under-voltage relay, auxiliary switch, alarm switch, rotary handle, pad locking device, etc to increase performance of the protection control.

(iv) The MCCB ampere frame rating ≤ 250 AF shall be thermal magnetic trip type and others shall be electronic trip type. Terminals of the MCCB rating ≤ 250 AF shall be cable lugs and the others shall be busbar terminals.

(v) Trip unit for the MCCB rating ≤ 250 AF shall be thermal-magnetic trip with adjustable thermal current from 0.7–1.0 time of rated Ampere-Frame (AF).

(vi) Trip unit for the MCCB rating ≥ 400 AF shall have rating plug to adjust ampere rating. The ampere rating can be adjusted from 0.1–1.0 time of rating plug for overload current, and 3-10 times of rating plug for short circuit current.

(vii) All circuit breakers rating ≥ 1000 AT shall be completed with ground fault sensor. The sensor shall have the following characteristic:

1) Ground-fault clearing time of main circuit breaker shall be more than the clearing time of feeder circuit breaker.
2) Ground fault pick-up current ≥ 200 A. (adjustable)
3) Time delay can be set at 0.1, 0.2, 0.3 and 0.4 Sec

(viii) All circuit breakers shall be equipped with rotary handles and pad locking facilities.

(ix) Main circuit breaker for the MCC shall be equipped with the following protective devices.

1) Phase sequence protection
2) Phase failure relay
3) Over and under voltage protection with time delay relay
4) Shunt Trip

(x) All circuit breakers shall be selected to perform in coordination pattern along the protective lines.

(f) Motor Starters

(i) Motor starters shall comply with the requirement in applicable standards of IEC as stipulated, or other standards as approved equivalent (or better).

(ii) Each starter shall be of an air break type and provided with thermal overcurrent trip unit (one on each phase). In case of intervention of the above trip units, an auxiliary contact shall release the starter coil off and give an alarm signal.

(iii) The thermal over current trip units shall be of the manually reset type, and suitable push buttons shall be provided on the door of each unit.

(iv) At least 2 normally open and 2 normally closed free contacts for both starting and tripping signals shall be provided. These free contacts shall be wired to the terminal blocks for remote indicator.

(v) Contacts of the motor starter shall be able to withstand interrupting current ≥ 10 times of the rated current of motor.

(vi) Automatic direct-on-line (DOL) starters are allowable for various motor sizes up to 7.5 HP (5.5 kW) and closed circuit transition reduced voltage (or Y-Δ) starters shall be used for those over 7.5 HP (5.5 kW).

(g) Measuring Devices and Instruments

(i) All measuring devices and instruments shall comply with the requirement in applicable standards of IEC as stipulated, or/and other standards as approved equivalent (or better).

(ii) Multifunctional Digital Power Meter (DPM)

1) The DPM, if applied, shall be panel mounted type, complete with LCD or LED display unit. The display unit shall have the minimum 3 rows with 7 characters per row for value monitoring. The meter shall be in compliance

with IEC 61326, IEC 61010-1 and IEC 62053-21 standard or other approved equivalent.

2) The DPM shall be able to measure true RMS values as follows (minimum):

a) Current : per phase

2) Voltage : V_{L-L} and V_{L-N}

3) Power : kW, kVAR, kVA per phase and total at 3 phases

4) Power Factor : per phase / average at 3 phases

5) Frequency : incoming electrical source (Hz.)

6) Energy : kWh, kVARh, kVAh (Class 0.5)

7) Harmonic : THDi and harmonic order from 3^{rd} up to 15^{th}

3) The DPM shall be completed with built-in RS-485, Mod bus communication port or RS-422 communication ports (2 ports) to interface with Building Management System (BMS) and/or SCADA System.

4) The DPM shall be operated at rated voltage not exceed 600 VL-L and current rating ≤ 5 A (from secondary of current transformer).

5) The accuracy of power meter shall be as follows:

1) Current / Voltage : 0.5 %

2) Power / Energy : 0.5 %

3) Power Factor : 0.5 %

(iii) Analog Meters

1) Each indicating instruments shall be semi-flush mounted, back connected, dustproof, fully tropicalized, switchboard type with a dull black case for mounting on a steel panel.

2) Except as otherwise specified, all indicating instruments shall be approximately 96 mm x 96 mm square with a 90^{o}C

scale arc. All meters shall be of the moving iron type. The maximum error of each indicating instrument shall not be more than 1% of full scale range.

3) The overload capacity is 1.25 times of the normal continuous load, except for motor circuit where the overload capacity of ammeter shall be 2.5 times the normal continuous load.

4) The ammeters for which the upper limited of the effective range does not exceed 20 amps may be direct (series) connected. For higher range, current transformer operated ammeter shall be used, and shall be designed for a secondary current of 5 amps.

5) Accuracy Class of the meters shall be 1.0 or better.

6) Voltmeters shall be the direct connection type with the accuracy class 1.0 (or better) and scale range: 0-500V.

(iv) Instrument Transformers

1) The current transformers shall be suitable for use with meters, and shall be tropical proof type with a 5A secondary and a primary rating equal to continuous current rating of circuit breaker. All current transformers shall have thermal and mechanical limits coordinated with the short-time rating of the circuit breakers with which they are used.

2) All current transformer secondary leads shall be brought out to shorting type terminal blocks located in the instrument compartments and shall be arranged to provide any combination of connections or polarity.

3) The current transformer shall not be used in dual-purpose role serving both instrument and protective device.

4) Accuracy Class of the current transformers shall be in accordance with the following function:

a) Non-tariff metering : 1.0

b) Switchboard indicating instrument : 1.0

c) Protection : 10P

5) The voltage transformer (if applied) shall be of the air-insulated type, with the windings encapsulated in epoxy resin or other suitable synthetic material. All voltage transformer secondary leads shall be brought out and connected, through secondary fuses, to terminal blocks for external connections or connection to other devices integral to the switchgear. These fuses and terminal blocks shall be mounted in the instrument compartments.

(v) Other Instruments and Accessories

1) On 3-phase, 4-wire systems, ammeter switches (if applied) shall have four operating positions, marked 'R', 'S', 'T' (or ‘A’, ‘B’, ‘C’), 'N', and 'OFF' position, and shall enable the single ammeter to read, in sequence, the currents in each of the three phases and the neutral wire. Ammeter switches shall have 'make-before-break' contacts.

2) On 3-phase, 4-wire systems, Voltmeter Switches (if applied) shall have seven operating positions, marked 'R-S', 'S-T', 'T-R', 'R-N', 'S-N', 'T-N', and 'OFF' position, and shall enable the single voltmeter to read, in sequence, each of the three line voltages and each of the three phase-to-neutral voltages. Voltmeter switches shall have 'break-before-make' contacts.

3) All indicating and pilot lamp assemblies shall be of the low power, cool operating, 24 V, switchboard type, with color caps and integrally mounted resistors. The color caps shall be Red, Yellow, and Blue. The lamp bulbs shall be replaceable from the front of the panels.

4) Undervoltage relay, if applied, shall be 3-phase, 4-wire, 415/240V, 50Hz unit. The undervoltage setting shall be adjustable to 10% with time delay setting 0-10s. The undervoltage relay shall include phase sequence and phase failure to trip the breaker when one phase falls symmetrically.

(h) Control Wiring and terminal blocks

(i) All control wires in the motor control center shall be flexible anneal stranded copper conductors with insulation for rated not less than 600V / 90^{o}C in compliance with IEC 60502.

(ii) The size of control wires shall be as follows:

1) 4 mm^2 for current circuit

2) 2.5 mm^2 for voltage circuit

3) 1.5 mm^2 for control circuit

(iii) The wiring shall be neatly and carefully installed in suitable wiring ducts with removable covers and shall be terminated at suitable terminal blocks. Splices shall not be permitted in control wiring or instrument leads. All hinged wiring shall be extra flexible.

(iv) Terminal block shall be spring type, screw-less, maintenance-free connection, and rail-mounted type. No current carrying metal shall be exposed after cables or terminal blocks accessories are connected.

(v) Wiring shall be identified at each end with a legible printed black marking sleeve. Sleeves shall be white tubing, sized to fit the insulation. Sleeves shall be able to rotate on the wire so not to inadvertently hide the wire number.

(3) Motors

(a) All motors shall comply with the latest ANSI or IEC standards or approved equivalent. They shall have ample margin on their rating for the required duty with due allowance for ambient temperature. All motor shall be induction type suitable for 50 Hz. Motors shall be of totally enclosed fan cooled squirrel cage screen-protect drip-proof type. High starting torque motors and low speed machines shall be started by reduced voltage starters.

(b) Motors shall normally be supplied by the manufacturer of the equipment driven by the motors.

(c) Control devices shall be provided for all motors. Single or double pole snap switches, specifically designed for alternating current operation only, may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating. Automatic control devices such as thermostats may control the starting and stopping of motors directly, provided the devices used are designed for that purpose and have such a rating. Otherwise, magnetic starters shall be used, with the automatic control device actuating the control circuit.

(d) All motors shall be provided with a disconnection means. All 3-phase and single-phase motors above 1 kW (1 ½ HP) shall be provided with a safety-type disconnecting switch. For single phase motors below 1 kW (1 ½ HP), a general use snap switch, rated for alternating-current only shall be acceptable, provided the ampere rating or the switch is at least 125 percent of the full load current rating of the associated motor. Switches shall disconnect all ungrounded conductors.

(4) Low Voltage Cables

(a) General Requirement

(i) Power cables will be single, two, three or four conductors depending on the design in the detailed design stage which being used in a 3-phase - 4-wire - 50 Hz / TN-S system.

(ii) All cables shall be selected suitably for indoor and outdoor installations, wet and dry locations, exposed to sunlight, in conduit, in cable tray, in wireway as appropriate.

(iii) The conductors shall be unbroken for the full length of the reels.

(iv) Cables for life safety equipment shall be fire resistance cables (FR).

(b) PVC insulated cable (if applied)

(i) The cables shall be formed of individually annealed copper solid or stranded wire with heat resistant Polyvinyl chloride (PVC) insulation material which has rated not less than 750 V 70OC in compliance with TIS 11-2553 standard.

(ii) All cables size 6 mm2 or larger shall be stranded.

(c) XLPE Insulated Cable (if applied)

(i) Conductors shall be of soft or anneal uncoated stranded copper wire Class 2 in accordance with IEC 60228 and shall have a concentric lay.

(ii) Insulation shall be of cross linked polyethylene (XLPE) insulated and black Polyvinyl chloride (PVC) outer sheathed, which have rated not less than 0.6/1.0 kV 90^{O}C in compliance with IEC 60502 standard.

(iii) For multi-core conductor cable, the component of cable shall consist of Conductors (2 or 3 or 4 cores), Insulation (XLPE), Filler, Binding Tape, and Outer Sheath (PVC). Filler shall be of non-hygroscopic material.

(d) Low Smoke/Zero Halogen Cable (LSF or LSOH or LSZH Cable) (if applied)

(i) Conductors shall be of soft or anneal uncoated stranded copper wire in accordance with IEC 60228.

(ii) Insulation shall be cross-linked polyethylene (XLPE) or polyolefin insulation which has thickness according to IEC 60502.

(iii) Outer sheath shall be of the low smoke/zero halogen material.

(iv) For multi-core conductor cable, the component of cable shall consist of Conductors (2 or 3 or 4 cores), Insulation, Filler, and Outer Sheath. Filler shall be of low smoke/zero halogen material.

(v) Rated voltage of cable shall be 0.6/1.0 kV.

(vi) Cable shall not generate toxic gases in event burnt.

(vii) Standard for testing of flame retardant shall be in compliance with IEC 60332-1 / -3.

(viii) Standard for testing of low smoke shall be in compliance with IEC 601034-2.

(ix) Standard for testing of toxic gas emission shall be in compliance with IEC 60754-2.

(x) Test reports shall be submitted for approval.

(e) Control Cable (CVV and CVVs) (if applied)

(i) All control cable shall be suitable for installation in wet and dry locations. The conductor shall be of soft or annealed strand uncoated copper wire.

(ii) The insulation shall be polyvinyl chloride (PVC) or polyethylene (PE) suitable for use on a copper conductor with a maximum operating temperature not less than 70^{o}C.

(iii) Filler shall be used in the interstice of the multi-conductor cable where necessary to give the complete cable a substantially circular cross section. Fillers shall be Polyvinyl chloride (PVC) rod or Polyethylene (PE) materials.

(iv) The cable shall be helically wrapped over the filler and copper shielding with non-hygroscopic Mylar or Polyester tape.

(v) The shielding, for CVVs cables, shall be annealed copper tape or suitable width and shall be helically applied with a minimum 10% lap. The annealed copper tape shall be a least 0.1 mm thickness and substantially free from burrs.

(vi) The outer sheath shall be of black polyvinyl chloride (PVC) jacket over the wrapping and shall comply in all respects with ICEA S61-402 standards.

(vii) For life safety equipment; the control cables shall be fire resistant type complying with the standards as shown in item (d) "Fire Resistant Cable".

(5) Raceway

All cables shall be laid in conduits, or in cable trays, or in wireways, or underground, or in cable trenches in accordance with the approved detailed design.

(a) Metal Conduits

(i) Rigid Steel Conduit (RSC), if applied, shall be steel and galvanized by the hot-dip process in compliance with NEMA ANSI C80.1 and complete with enamel finished inside the tube.

(ii) Intermediate Metal Conduit (IMC) shall be steel and galvanized by the hot-dip process in compliance with MENA ANSI C80.6 and complete with enamel finished inside the tube.

(iii) Electrical Metallic Tubing (EMT), if applied, shall be steel and galvanized by the hot-dip process in compliance with NEMA ANSI C80.3 and complete with enamel finished inside the tube.

(iv) Flexible Metal Conduit (FMC) shall be made from galvanized steel. The FMC installed in wet locations shall be of the liquid-tight type.

(v) Flexible conduit and fittings for life safety equipment shall be galvanized water-tight pattern, frame retardant; LSOH over-sheathed and separated earth wire enclosed within the conduit.

(vi) Conduit fittings and conduit bodies shall be galvanized steel in compliance with ANSI/NENA FB 1 standard.

(vii) The finished conduit and fittings shall have smooth surface for wire pulling, and shall not have any lumps of excess zinc and other injurious deflects to damage the wire.

(viii) The outside surface and threads on conduit shall have protective coating against corrosion. The threads on the fittings shall have paint, zinc or other protective coating against corrosion.

(ix) The standard manufactured Elbows shall be used for all sizes of conduits larger than 25 mm. (1 inch). The field bends to be handles with great care not to damage the conduits, will be permitted for conduit of 25 mm. (1 inch) and smaller.

(x) Conduit expansion joints shall be provided at building expansion joints. Metallic expansion fittings to ensure grounding continuity shall be applied.

(xi) Conduits and accessories installed in all **Stations** shall be capable of being subject to temperatures up to 500^{O}C for 1 hour and shall not support combustion under the same temperature, in accordance with NFPA 130.

(xii) The following table shall be the comparison of nominal diameters of conduit in inches and in mm.

Conduit Diameter in Inches										
Conduit Diameter in mm										

(b) Non-metallic Conduit (if applied)

(i) Polyethylene Conduit shall be high density polyethylene (HDPE) type in compliance with ASTM D1248:

1) Class I: For embedding under road or street.

2) Class II: For embedding under pavement or footpath

(c) Cable Tray (if applied)

(i) Cable trays shall be of a perforated/corrugated pattern with lid, 2.0 mm minimum thickness mild steel with returned edges and hot-dip galvanized overall after fabrication in compliance with ASTM A123/A123M standard.

(ii) Cable trays and supports shall be capable of being subject to temperatures up to 500^{O}C for 1 hour and shall not support combustion under the same temperature.

(iii) Fittings (such as tees, angle pieces, connectors) shall be of the same type of cable tray.

(iv) On site cutting of hot dipped galvanized components shall be properly repaired in the field using cold galvanizer.

(v) Support brackets and rods shall be of hot-dipped galvanized steel. Minimum mean coating thickness of the hot dipped galvanization shall be 65 micron. All bolts and nuts shall be electroplated with zinc with a minimum plating thickness of 25 micron.

(vi) Each section of the cable tray shall be electrically bonded, with a minimum 6 mm^2 cross section area earth-bonding strap or wire, to the next section to form an electrically continuous system and bonded to the main grounding system with green/yellow PVC insulated copper, single core cable. All edges, fittings, or any parts of the cable trays shall be finished free from bar, sharp edges, or projections damaging to the insulation or jacket of the cables.

(vii) 40% spare space capacity shall be provided for future cables laying inside the cable tray.

(d) Wireways (if applied)

(i) Wireways shall be made of hot-dip galvanized after fabrication to afford good corrosion resistance during storage, installation and service life. The minimum thickness required for wireways shall be as the following table (in millimeter unit):

Size of wireways (width x height)	Thickness
50 x 50 up to 100 x 50	1.2
100 x 100 up to 150 x 100	1.2
200 x 100 up to 300 x 100	1.6
150 x 150 up to 300 x 150	1.6
Larger than above	2.0

(ii) Wireways and supports shall be capable of being subject to temperatures up to 500^{O}C for 1 hour and shall not support combustion under the same temperature.

(iii) Fittings of wirewas shall be of the same type of cable tray.

(iv) On site cutting of hot-dipped galvanized components shall be properly repaired in the field using cold galvanizer.

(v) Support brackets and rods shall be of hot-dipped galvanized steel. Minimum mean coating thickness of the hot dipped galvanization shall be 65 micron. All bolts and nuts shall be electroplated with zinc with a minimum plating thickness of 25 micron.

(vi) Each section of the wireways shall be electrically bonded, with a minimum 6 mm2 cross section area earth-bonding strap or wire, to the next section to form an electrically continuous system and bonded to the main grounding system with green/yellow PVC insulated copper, single core cable. All edges, fittings, or any parts of the wireways shall be finished free from bar, sharp edges, or projections damaging to the insulation or jacket of the cables.

(vii) 40% spare space capacity shall be provided for future cables laying inside the wireways.

(6) Boxes and Accessories

(a) Outlet Boxes

(i) For wall/column recessed, the boxes shall be of steel sheet with not less than 1 mm thickness with hot-dip galvanized after fabrication, and completed with adjustable lug, ample knocked-holes and brass earth terminals fitted within the box.

(ii) For exposed works; the boxes shall be of die-cast aluminium, and completed with threaded hubs, neoprene gasket and earth terminal fitted within the box. The boxes shall be allowed for outdoor works in accordance with IP65 protection class.

(iii) The internal depth of a box shall be not less than 32 mm.

(iv) The corners of a box shall be mechanically and electrically continuous.

(b) Pull Boxes and Junction Boxes

(i) Pull boxes and junction boxes for branch circuits, indoor used, shall be as the same type of the outlet boxes and to be equipped with galvanized steel cover plate fastened with stainless steel screws.

(ii) Pull boxes and junction boxes for branch circuits, outdoor used, shall be of die-cast aluminium circular box completed with threaded hubs, earth terminal fitted within the box and fastening cover with neoprene gasket for IP65 protection class.

(iii) Pull boxes, which are used in feeder system (main feeders or feeders or sub-feeders), shall be made of steel sheet with not less than 1.6 mm thickness with hot-dip galvanized after fabrication, completed with ground flange, neoprene gasket and lid fastened with stainless steel screws. The boxes where used on outdoor location shall be IP65 protection class.

(iv) The corners of a box shall be mechanically and electrically continuous.

(v) Size of the pull boxes and junction boxes shall be selected in compliance with NFPA 70 and EIT 2001-56 standards.

(7) *Safety Switch*

(a) The safety switches shall be either Fused Safety Switches or Non-Fused Safety Switches as required on the approved detailed design.

(b) The switches shall be heavy duty type equipped with switch blades, a quick-make and quick-break operating handle and mechanism which shall be an integral part of the box. Service door of each safety switch shall be interlocked so that it cannot be opened while the switch is in "ON" position.

(c) Current rating of the switches shall be as approved at the detail design stage.

(d) All fuses for "fused safety switch" shall be of the high rupturing capacity (HRC) type of voltage rating up to 600 volts. Current rating shall be suitable for equipment loading.

(e) The switches shall be IP 31/NEMA 12 general purpose enclosure with knockouts unless otherwise noted or required. Switches (sealed) located outdoor or in wet areas shall have IP 54/NEMA 3 enclosures.

(8) *Power Distribution Boards (if applied)*

(a) General

(i) The distribution boards shall be of metal-enclosed indoor, factory-built type, and suitable for the 415/240 V – 3Ø – 4-Wire – 50 Hz system. A minimum protection of enclosure IP31 shall be provided. All distribution boards shall be provided with incoming and outgoing LED indication lights.

(ii) Before installing a distribution board, the Private Party shall check all the architectural drawings for possible conflicts of space, and adjust the location of the panel board to prevent such conflicts with other items.

(b) Panel Construction

(i) The distribution board enclosure shall be made of electro-galvanized steel sheet (minimum thickness 2 mm) and finished with epoxy-powder coating (minimum 60 micron) colored to the Engineer's representative's acceptance. The enclosure shall be completed with hinged doors and to be provided with standardized key lock and 3 sets of keys shall be provided for each distribution board. All DB doors shall be provided with separate latches in addition to the door locks.

(ii) The distribution panelboards shall be supplied fully equipped, wired, and proofed against vermin, dust and moisture, designed for free-standing or for wall-mounting, and cable access from beneath or above. Proper warning signs indicating danger and voltage level shall be provided.

(iii) Unless otherwise accepted, access to the boards shall be from the front, the doors shall be furnished with lift-off hinges to permit an opening enabling an unrestricted access to the board interior. All doors and covers shall be fitted with moulded gaskets of non-ageing material.

(iv) The distribution panelboards shall be provided with 3-phase tinned copper conductor busbars rated for continuous current and short circuit current. The busbars shall be designed to withstand dynamic forces due to peak short circuit current. All busbars including droppers and termination to the circuit breakers shall be color-coded conforming to the color coding as stipulated.

(v) Each distribution panelboard shall also be equipped with neutral busbar having the same rating as the phase-buses, and Earth busbar rating as 33% of the phase-buses.

(vi) As-built single line diagram, control circuit and layout plan shall be inserted in a permanent pocket on the inner side of the panel door of each distribution board.

(c) Circuit Breakers

(i) The circuit breakers installed in the distribution boards shall be moulded case circuit breakers (MCCB) complying with IEC 60947-1 and IEC 60947-2 standard.

(ii) Other requirement for them shall refer to clause 3.10.2.2 (2) (e) “Moulded Case Circuit Breaker”

(d) Measuring Devices and Instruments

(i) Multifunctional digital power meters, if applied, shall refer to the specification as described in Clause 3.10.2.2 (2) (g) (ii).

(ii) Analog Meters, if applied, shall refer to the specification as described in Clause 3.10.2.2 (2) (g) (iii).

(iii) Instrument Transformers, if applied, shall refer to the specification as described in Clause 3.10.2.2 (2) (g) (iv).

(iv) Other instruments and accessories shall refer to the specification as described in Clause 3.10.2.2 (2) (g) (v) for one or more items are applied in the design.

(e) Internal cabling

(i) All internal cabling in each item of equipment shall be installed in cabling channels or conduits. Exposed cabling shall be kept to a minimum but where necessary, the wires shall be formed into compact groups suitably bound together and properly supported.

(ii) All conductors shall be terminated with suitable pressure type terminal lugs of proper sizes for terminal studs at the terminal blocks or shall be terminated in a manner compatible to the terminals of the instruments.

(iii) All conductors shall run continuously between terminal studs without splices or taps and all conductors shall be labeled at each termination with wire number as designated on the circuit diagrams.

(iv) All internal cabling shall be insulated anneal stranded copper wire, rated at not less than 600V / 90^{o}C. And minimum cross-sectional area shall be;

1) 1.5 mm^2 for control circuits

2) 2.5 mm^2 for voltage and current circuits

3.10.3 Execution

3.10.3.1 Installation

(1) The Private Party shall install the Electrical and Control Works in accordance with the approved Working Drawings and manufacturer’s instructions, and in compliance with the requirement of NFPA 70; EIT 2001-56; and the recommendation of MEA.

(2) The floor-standing type of the Motor Control Centers and Power Distribution Boards (if applied) shall be installed on the concrete base 150 mm. heights.

(3) The wall-mounting type of the Motor Control Centers and Power Distribution Boards (if applied), generally, shall be mounted rigidly with expansion bolts on concrete or nuts and bolts on wooden or metal wall at a height of 1,800 mm. above the finished floor to top of the panels.

(4) All metal and non-carrying current parts shall be grounded.

(5) Low Voltage Cables

(a) In general, the Power cables shall be run in conduits, in cable tray and shall be run concealed in ceiling, floor, and wall or as indicated on the approved Working Drawings.

(b) No wire shall be pulled into the conduit system until it is complete in all details.

(c) Lubricant shall be used to facilitate wire pulling. Lubricants shall be approved for using with the insulation specified.

(d) Splicing of wires and cables shall be allowed only in the luminaires, receptacles and proper junction box with an approved method of insulation. No splice shall be made in conductors for instrument circuits or control circuits.

(e) Splicing of large wires and cables shall be by compression type, solderless wire connectors indented by special hydraulic tool. The splice shall be insulated with plastic insulation tape such as Scotch Brand No.35. Thickness of the tape shall not be less than three layers or at least the same thickness as the wire insulation.

(f) Compression type, solderless lugs indented by proper tool shall be used at the end of all wires and cables and shall be connected to the screw type terminals of the equipment and to the bus bars.

(g) The cut end of cables shall be treated to prevent seepage of water into the cable.

(h) The Private Party shall provide all necessary materials for installation of the cables, such as grounding lead wires, compression type terminals, metal fitting, bolts and nuts including cable identification and felt packing to be inserted between cable and cleats.

(i) The unoccupied space in cable knockouts and conduits after cable insertion shall be filled, with duct seal to prevent insects and small animals from entering the equipment housing.

(j) Where cables are buried in the ground the minimum depth of burial shall be 0.6 m. Cables shall be laid on 0.15 m and covered by a 7.5 cm. layer of clean sand. Cables shall be covered with tiles and or marking tape and the trenches backfilled to grade level.

(k) Cables under roads shall be enclosed in ducts supplied and installed by the electrical work.

(l) All cables shall be identified by means of cable tags fitted to each termination point and at 30 meter intervals along cable route.

(m) Cable route markers shall be installed above ground along underground cable routes. These shall be located at 30 meter inter- intervals, at changes of direction and at entries to buildings.

(n) The Private Party shall be responsible for the supervision of the cable trench excavation, sanding and backfilling, supply and installation to warning tape, cable tiles and cable marker posts as detailed on the approved Working Drawings and in these Specifications.

(o) Cables shall be laid in one continuous length.

(p) Conductors with compression type terminals and insulation cover shall be arranged in a neat manner on terminal box or equivalent terminals. The Private Party shall install plastic cable tie-wraps as required to neatly group cables and to keep the weight of the cable from damaging terminations.

(q) The conductors in vertical raceways shall be supported if the vertical rise exceeds the values in following table:

Spacing for Conductor Supports in Vertical Raceway		
Size of Cable (mm^2)	**Maximum Spacing (m)**	**Remark**
50 or smaller	30	If the vertical run is less than 25% of max. Spacing in table, cable supports will not be required.
70 thru 120	24	
150 thru 185	18	
240	15	
300	12	
over 300	10	

(6) Conduits & Accessories

(a) All conduits shall be as specified herein with a minimum size of 15 mm. unless otherwise noted.

(b) Where the conduits enter the cabinets and equipment, conduit bushings and double locknuts shall be used.

(c) The end of all conduits shall be tightly plugged to exclude dust and moisture while the buildings are under construction.

(d) The bending radius of the conduit shall not be less than six times the outer diameter of the conduits. The total bending angles of conduits shall not exceed 360 degrees in any one run.

(e) The conduits used shall not have any internal and external defects. Each end of the conduit shall be made smooth with the conduit reamer to prevent damage to the wire.

(f) A short piece of flexible metal conduit shall be used for connecting all motors, vibrating equipment, recess lighting fixtures and junction boxes and as otherwise specified.

(g) The wiring system shall consist of PVC insulated cables drawn into conduit. Wiring shall be loop-in style without joints.

(h) The wiring capacity of conduits shall conform to the requirement in EIT Standard 2001-56 and/or the current edition of NFPA 70.

(i) Conduit shall be run neatly on the surface or buried within the carcase of the buildings as indicated on the approved Working Drawings and in these Specifications. Conduit shall be run at least 0.15 m. clear of plumbing and mechanical services.

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

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

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

(m) Provide suitable fittings to accommodate expansion and deflection where conduit crosses seismic, control and expansion joints.

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

(7) Cable Trays

(a) The supports for horizontally run-cable tray shall be provided such that they shall be capable to adjust vertically. Where tray and ladder systems are supported by drop rods additional restraints shall be included to provide adequate lateral support. Restraints shall be installed at all bends and intersections and at intervals not exceeding 1.5 meters on straight runs. Support rods shall be at least 6 mm diameter. Trapeze or other hangers shall be clamped on the drop rods between two nuts.

(b) Cable tray or ladder shall not be installed across building or structural expansion joints. On horizontal runs the tray or ladder shall be installed with a 20 mm gap at the expansion joint. Supports shall be installed within 150 mm on either side of the joint.

(c) Provide all openings on floors and walls necessary for cable trays unless indicated as being provided by others.

(8) Wireways

(a) All length of the wireways shall be supported by the metal hangers at every interval not more than 1.50 m for horizontal and vertical installation. The supports for horizontal run shall be provided such that shall be able to adjust vertically for neat alignment.

(b) Provide all openings on floors and walls necessary for wireways unless indicated as being provided by others.

(9) The Conduits, cable trays, wireways and termination boxes for Electrical system shall have to be painted strip color coding at interval 1 m along total length of raceways with;

(a) Normal Power : Orange

(b) Essential Power : Yellow

(c) Control system : Blue

3.10.3.2 Testing and Commissioning

(1) Motor Control Centers / Power Distribution Boards

(a) All motor control centers / power distribution boards shall be not only tested at the manufactory but also checked at the site for the following performances.

(i) Insulation of all cables

(ii) Operating and protecting of the equipment

(iii) Grounding

(2) Low Voltage Cables

(a) All cables fed to the equipment shall be meggered phase-to-phase and phase-to-ground before the equipment is connected and phase-to-ground after the equipment is connected and all connection are tapped.

(b) Insulation resistance tests shall be performed by using a 500 Vdc megger on the 400 volts system. Insulation resistance shall be not less than one mega ohms per 1000 volts rating.

3.11 FIRE BARRIER WORK

3.11.1 General

3.11.1.1 General Requirement

(1) After erection of materials and equipment through wall and opening had been completed, it is the responsibility of the Private Party to fill up voids and openings with fire resistant material which conform to NFPA AND NEC article 300-21 and ASTM to protect fire or smoke from spreading out from one room to another room through these voids and openings.

(2) The applied to wall considered to be a fire or acoustical protection wall, unless otherwise specified. Cover or escutcheon plates shall be provided, wherever exposed, and shall be neatly placed to the satisfaction of the Engineer's Representative.

(3) Also, after the erection of all pipe, ducts conduits, wirings, and raceways in the shaft, block-out or any floor openings, the voids must be sealed with 2-hours fire rating material, as approved by the Engineer's Representative unless specified otherwise.

3.11.1.2 Standard and Reference

(1) The fire barrier shall comply with the following codes and standards.

(a) Fire Protection Association (NFPA)

(b) Underwriters Laboratories, Inc. (UL)

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

3.11.1.3 Submittals

(1) The Private Party shall submit all material , catalog, material lists and technical data request for approval before installation.

(2) The method of fire barrier material installations must be submitted to the Engineer's Representative for approval before installation.

3.11.1.4 Warranty

(1) All part or the fire barrier work shall be guaranteed by the Private Party at least 2 years.

3.11.2 Materials

3.11.2.1 Description

The fire barrier materials shall be based on the standards of Underwriter's Laboratory Inc.

(1) The fire barrier materials shall be of minimum 2 hour fire resistant rating.

(2) The fire barrier materials must not be toxic during installation or incase of fire.

(3) Easy to be dismantled and replaced in case of rearrangement.

(4) Withstand over vibration.

(5) Easy installation.

(6) Before and after fire spreads, the fire barrier materials must be strong enough.

(7) The fire barrier materials must be submitted to the Engineer's Representative for approval before installation.

3.11.3 Execution

3.11.3.1 Installation

(1) At every voids and openings, fire barrier materials shall be installed where

(a) Every voids, sleeves, and openings appear on wall, floor, beam and shaft, provided for raceway installation, must be sealed after the erection work had been completed.

(b) Voids, sleeves, and openings which are provided for future installation.

(c) Voids between electrical conduits and sleeves.

(d) Voids between electrical cabling and raceway on fire wall and floor.

(e) Voids between raceway and sleeves on fire wall and floor.

3.12 PAINTING

3.12.1 General

3.12.1.1 General Requirement

(1) Prior to equipment installation all metal surfaces shall be treated with anticorrosive materials and/or painted according to this specification.

(2) The preparation and application of the painting materials shall adhere strictly to the manufacturer's recommendations.

(3) The equipment or materials that have previously been treated with anticorrosive materials and painted from the factory must be inspected for their workmanship. Any defects, such as scratches, peels and rust shall be repaired and repainted to the approval of the Engineer's Representative.

(4) During the progress of the paint work, the Private Party shall avoid spotting of the floors, walls and other adjacent equipment. All spotting, if any, shall be cleaned immediately. Any damages, which may result from painting shall be under the Private Party's responsibility.

3.12.2 Material (Not used).

3.12.3 Execution

3.12.3.1 Painting

(1) Preparation and Cleaning of Surface to be Painted

(a) Metal or Ferrous Metal Surfaces

Rust at welding joints and other defects shall be removed by scraping. Wire brushes or sand papers shall be used to clean the surfaces and to remove rust. Sand-blasting may be used to remove loose rust and other foreign substances. Mordant solution such thinner, gas, terpentine shall be used to remove grease, oil or organic coating. Then the surface shall be cleaned with water and thoroughly dried or blow-dried.

(b) The application of prime coats which follows shall adhere strictly to the manufacturer's recommendations.

(c) Old paint coats shall be removed by scraping before application of new paint.

(2) Brush or Spray Painting

Each paint coat shall be left until completely dry before subsequent applications.

Painting can be classified into 2 coats :

(a) Prime coat for rust prevention and/or adhesion of the finishing coats.

(b) Finishing coat for final appearance or for symbolizing the system codes. Types of paint used shall depend on the material as well as on the environment.

(3) Types of Paint for Various Surface and Environment

Type of Surface	Normal Area or Corrosive Area	Humid Area
Black steel pipe, black steel hanger and support, black steel sheet, switchboard, and panel.	1st coat: Red lead primer 2nd coat: Red Lead primer 3rd coat : Alkyd finishing paint. 4th coat : Alkyd finishing paint.	1st coat: Epoxy red lead primer. 2nd coat: Epoxy red lead primer. 3rd coat : Epoxy finishing paint. 4th coat : Epoxy finishing paint.

Type of Surface	Normal Area or Corrosive Area	Humid Area
Galvanized steel pipe, galvanized steel hanger and support, and gal- vanized steel sheet. If colour coding is not specified, bronze colour shall be used for finishing coat.	1st coat : Wash primer 2nd coat : Zinc chromate primer 3rd coat : Alkyd finishing paint 4th coat : Alkyd finishing paint	1st coat : Wash primer 2nd coat : Zinc chromate primer 3rd coat : Epoxy finishing paint 4th coat : Epoxy finishing paint
PVC pipe, plastic pipe.	1st coat : Wash primer 2nd coat : Chlorinated rubber finishing- paint 3rd coat : Chlorinated rubber finishing paint	1st coat : Wash primer 2nd coat : Chlorinated rubber finishing paint. 3rd coat : Chlorinated rubber finishing paint.
Cast-iron pipe inclusive of underground pipe.	1st coat : Coal tar epoxy 2nd coat : Coal tar epoxy	1st coat : Coal tar epoxy 2nd coat : Coal tar epoxy
Copper tube, stainless steel pipe, stainless steel sheet, aluminium steel pipe, aluminium steel sheet, light alloy, lead, and conduct clamp.	1st coat : Wash primer 2nd coat : Alkyd finishing paint 3rd coat : Alkyd finishing paint	1st coat : Wash primer 2nd coat : Epoxy finishing paint 3rd coat : Epoxy finishing paint
Closed cell foam plastic. Use colour tape strips to indicate colour codes.		

Note: In case where there is a paint repair resulting from welding, cutting, drilling, polishing, or threading, zinc rich primer shall be used prior to the application of finishing paint.

(4) Colour Code

(a) All pipes shall be colour coded except insulated pipes where only priming coats shall be applied to the pipe surface.

(b) In the electrical system, colour coding shall be only at the conduit clamps and the cover of junction boxes.

(c) Strip sizes of colour codes (for insulated pipes) and the letter size are as follows :-

Pipe Size (mm.)	Width of Colour Strip (mm.)	Letter Size (mm.)
20 (3/4”) – 32 (1¼”)	200 (8”)	12 (1/2”)
40 (1½”) – 50 (2”)	200 (8”)	20 (3/4”)
65 (2½”) – 150 (6”)	300 (12”)	30 (1¼”)
200 (8”) – 250 (10”)	300 (12”)	65 (1½”)
300 (12”) and larger	500 (20”)	100 (4”)

(d) Location of symbols and arrows indicating directions are as follows :

(i) Every 6 metre (20 ft.) internal of straight line pipe.

(ii) Near all valves.

(iii) Every change of direction and/or separation.

(iv) Where pipes passing through walls or floors.

(v) Near service pipe.

(5) Colour Codes of Various Systems

(a) The identifications previously mentioned shall have colour as follows :

Description Code	Letters Symbol	Colour Code	Colour Symbol
Cold Water Supply	CWS	Green	White
Cold Water Supply to Water Storage	CWT	Green	White
Soft Water	SF	Green	White
Drinking Water	DW	-	White
Rainwater	RL	Light Green	White
Waste	W	Brown	White
Soil	S	Black	White
Vent	V	Yellow	Black
Sink Waste	SK	Purple	White
Conduit & Tray for Electrical for Sanitary System	SAN	Blue	Blue
Fire Protection	FD	Red	White
Drain pipe	D	Green	Black
Conduit & Tray for Electrical for Fire	FP	Orange	Red
Pipe Support & Hanger	-	Dark Gray	-

Description Code	Letters Symbol	Colour Code	Colour Symbol
Distribution Board & Motor Control Board Normal Electrical	-	Ivory	Black
Distribution Board & Motor Control Board Emergency Electrical	-	Ivory	Red

(b) Final selection of colours will be made by the Engineer's Representative. All uninsulated pipes painted all over the pipe surface conforming to this colour codes.

3.13 TEST AND STERILIZATIONS

3.13.1 General

3.13.1.1 General Requirement

(1) All piping shall be tested by the Private Party and approved by the Engineer's Representative before acceptance.

(2) All equipment, materials, labour, etc. required for testing the sanitary system or the part thereof shall be furnished by the Private Party.

(3) All new, altered, extended or replaced plumbing shall be left uncovered and unconcealed until it has been tested and approved.

(4) Where such work has been covered or concealed before it is tested and approved, it shall be exposed for testing.

(5) Underground plumbing shall be tested and approved before back filling.

3.13.1.2 Standard and Reference

Test and sterilizations shall comply with the following codes and standards.

(1) American Society of Mechanical Engineers (ASTM)

3.13.2 Material

Not used.

3.13.3 Execution

3.13.3.1 Drainage and Venting System Piping

Drainage and venting system piping shall be tested with water or air before the fixture are installed. After the plumbing fixtures have been set and their traps filled with water, the entire drainage and venting system shall be submitted for a final test.

(1) Water Test

Water test shall be applied to the drainage and venting system either in its entirely or in sections. If the entire system is tested, all openings except the highest one in the pipes shall be tightly closed. Then the system shall be filled with water to the point of overflow. If the system is tested in sections, each opening of the section under test shall be tightly plugged, and each section shall be filled with water and tested with at least 3 m. head of water. In testing successive sections, at least the upper 3.00 meters of the next preceding section shall be tested so that each joint or pipe in the building except the uppermost 3.00 m. of the system has been submitted to a test of at least a 3.00 m. head of water. The water shall be kept in the system, or in the portion under test, for at least 15 minutes before the inspection starts. The system shall then be tightened at all joints.

(2) Air Test

The air test shall be made by attaching an air compressor testing apparatus to any suitable opening and, after closing all other inlets and outlets to the system, force air into the system until there is a uniform gauge pressure of 0.35 kg/cm2 or sufficient to balance a column of mercury 250 mm. in height. This pressure shall be held without introduction of additional air for a period of at least fifteen (15) minutes.

3.13.3.2 Water System

(1) Piping

When the roughing-in is completed and before fixture are set, the entire hot- water and cold-water piping systems shall be tested at hydrostatic pressure of not less than 6.9 kg/cm2, and proved tight at this pressure for not less than 30 minutes in order to permit inspection of all joints. Where a portion of the water-piping system is to be concealed before completion, this portion shall be tested separately as specified for the entire system.

3.13.3.3 Defective Work

(1) If the inspection or test shows defects, such defective work or material shall be replaced or repaired as necessary. Then inspection and tests shall be repeated. Repairs of piping shall be made with new materials. No caulking of screwed joints or holes will be acceptable.

3.13.3.4 Cleaning and Adjusting

(1) Equipment, pipes, valves, fittings, and fixtures shall be clean without grease, metal cuttings, or sludge that may have accumulated from operation of the system during the test. Any stoppage, discolouration, or other damage to the finish, furnishings, or parts of the building, due to the Private Party's failure of cleaning the piping system properly, shall be repaired by the Private Party. When the Works is completed, the hot water system shall be adjusted for uniform circulation. Flush valves and automatic control devices shall be adjusted for proper operation.

3.13.3.5 Sterilization

(1) After pressure tests have been made, the entire domestic water-distribution system to be sterilized shall be thoroughly flushed with water until all entrained dirt and mud have been removed before introducing chlorinating material. The chlorinating material shall be either liquid chlorine or hypochlorite. The chlorinating material shall provide a dosage of not less than 50 ppm. and shall be introduced into the system in an approved manner. The treated water shall be retained in the pipe long enough to destroy all nonspore-forming bacteria. Except where a shorter period is approved, the retention time shall be at least 24 hours and shall produce not less than 10 ppm. of chlorine at the extreme and of the system of the retention period. All valves in the system being sterilized shall be opened and closed several times during the contact period.

(2) The system shall then be flushed with clean water until the residual chlorine is reduced to less than 0.2 ppm. During the flushing period all valves and faucets shall be turned on and off several times.

3.13.3.6 Report

(1) After installations are completed, all equipment shall be test run. Any adjustments that are needed shall be made to assure that all equipment will operate with the required performance. Test run reports with all necessary data such as pressure, temperature, flow rate, current, voltage, etc., shall be recorded.

SECTION 4

FIRE PROTECTION SYSTEM

4.0 GENERAL SPECIFICATION FOR FIRE PROTECTION SYSTEM

4.0.1 General

4.0.1.1 Introduction

(1) This general specification and requirement describe the materials and installation of the Fire Protection works for building services works and related work for the project.

(2) The work shall be executed to completion and in conformity with this specification

4.0.1.2 Operation

(1) Where the Private Party propose to use material and/or equipment which is not specified or detailed on the drawings, the matter shall be brought immediately to the attention of the Engineer's Representative who will make a decision.

(2) The locations of fire protection equipment, outlets, piping route and accessories shown on the drawings are diagrammatic, and shall be considered as approximate only. The approved locations may be different from those shown on the drawings, if so directed by the SRT.

4.0.1.3 Environment

(1) The material and equipment shall be installed as shown on the drawings and shall be suitable for tropical climate as mentioned below.

(2) Weather conditions for material and general equipment selection :

(a) Altitude : Approximately mean sea level

(b) Maximum temperature 40°C (104°F)

(c) Average temperature (all year) 30°C (86°F)

(d) Maximum relative humidity 85%

(e) Average relative humidity (all year) 60%

4.0.1.4 Standards, Codes and Regulations

(1) The entire system and its basic components shall conform in all respects to the standards and regulations of National Fire Protection Association (NFPA). The following standards are mentioned in these Specifications for systems and/or components and, where described, the systems and/or components shall conform to such standards.

(a) ANSI - American National Standard Institute

(b) API - American Petroleum Institute

(c) ASHRAE - American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc.

(d) ASPE - American Society of Plumbing Engineer.

(e) ASTM - American Society of Testing Materials

(f) AWS - American Welding Society

(g) AWWA - American Water Works Association

(h) BS EN - British Standard / European Standard

(i) CTC - Canadian Transport Commission

(j) DIN - Deutsher Industrie Normen (German Industrial Standard)

(k) DOT - U.S. Department of Transportation

(l) EIT - The Engineering Institute of Thailand

(m) LPCB - Listed of Approved Fire and Security Products and Services

(n) FM - Factory Mutual

(o) IEC - International Electro Technical Commission

(p) MEA - Metropolitan Electricity Authority

(q) MWWA - Metropolitan Water Works Association

(r) NEC - National Electrical Code

(s) NFC - National Fire Code

(t) NEMA - National Electrical Manufacturers Association

(u) PEA - Provincial Electricity Authority

(v) TISI - Thai Industrial Standard Institute

(w) TPED - EU Standard in Transportable Pressure Equipment Directive

(x) UL - Underwriter's Laboratories, Inc.

(y) VDE - Verband Deutsher Electro techniker (German Electrical Regulation and Codes)

(z) Any regulations issued by local authorities.

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

4.0.1.5 Scope of Work

(1) The scope of work of the Private Party shall include provision, installation, testing and balancing, commissioning of equipment and accessories as shown on the Drawings and Specifications to achieve a complete sanitary system.

(2) The system shall include the following:-

(a) Fire protection system

(b) Fire alarm systems

(c) Clean agent fire suppression system

(d) Foam-Water Sprinkler and Foam-Water Spray system

(e) Electrical power and control

(f) Accessories as required to complete the system

(3) It shall be the Private Partys responsibility to provide a completely safe and workable system in accordance with the requirements of these Specifications, and the accompanying drawings and schedules all to the entire satisfaction of the Engineer’s Representative.

(4) The Private Party shall coordinate with other trades to ensure that the system and its components furnished form a complete electrical and communication system with the established construction schedule.

4.0.1.6 Examination of Drawings and Specifications

(1) The Private Party shall examine all Drawings and Specifications to make sure that all requirements are thoroughly understood. In cases where, in his opinion, there are omissions and/or errors in any of these documents, he shall inform the Engineer's Representative immediately.

(2) The Private Party shall examine all relevant architectural and structural drawings together with all other utilities systems involved in the Project, prior to installation of machines, materials and equipment.

(3) Figure dimension as indicated on the Drawings are to be followed and in no case dimensions shall be scale from the Drawings. Wherever possible, dimensions are to be measured from the building. Before the Private Party commences any works, he shall ensure that dimensions are checked on the site and/or building and agree with those on the Drawings. The Private Party shall be responsible for the accuracy of such dimensions regardless of the comparable dimensions on the Drawings.

4.0.1.7 Dimensions

(1) Figured dimensions as indicated on the drawings are to be followed and in no case shall dimensions be scaled from the drawings. Wherever possible, dimensions are to be measured from the building.

(2) Before the Private Party commence any works, he shall ensure that dimensions are checked on the site and/or building and agree with those on the drawings.

(3) The Private Party shall be responsible for the accuracy of such dimensions regardless of the comparable dimensions of the drawings.

4.0.1.8 Operation

(1) Where the Private Party propose to use material and/or equipment which is not specified or detailed on the drawings, the matter shall be brought immediately to the attention of the Engineer's Representative who will make a decision.

(2) The locations of fire protection equipment, outlets, piping route and accessories shown on the drawings are diagrammatic, and shall be considered as approximate only. The approved locations may be different from those shown on the drawings, if so directed by the SRT.

4.0.2 Material

4.0.2.1 Material and Equipment

(1) All Fire Protection equipment, materials and parts used shall be new and unused, of the highest quality and free from defects or imperfections affecting the performance or life of the item and of current manufacture approved by the Engineer's Representative.

(2) Unless otherwise specifically indicated on the Drawings or in the specification, all materials and equipment shall be installed, with the approval of the Engineer's Representative, in accordance with recommendations of the manufacturer. However, the approval of the Engineer's Representative shall not release the Private Party from his responsibility or his liability regarding the properties of installations.

(3) The Private Party shall protect all electrical equipment, materials and parts during storage and during construction against the ingress of moisture, contamination or corrosion that might damage the finish or lower the electrical integrity of the item.

(4) Certain major electrical equipment defined in the Specifications will be furnished to the Private Party, on site. The Private Party shall assemble, align, level and fix this equipment as instructed by the manufacturer and to the Engineer's Representative's satisfaction. In this case herein specified (if any).

(5) After the material and equipment have been installed completely in accordance with the instructions, the Private Party shall be responsible for protecting the material and equipment from damages

4.0.2.2 Equipment Deviations

(1) Where the Private Party proposes to use an item of equipment other than that specified or detailed on the Drawings, requiring any redesign of the structure, partitions, foundations, piping, wiring or any other part of the mechanical, electrical, structural or architectural layout, all such redesign, including drawings and detailing required shall be prepared by the Private Party and then approved by the Engineer’s Representative.

(2) The deviation shall be approved and instructed by the Engineer’s Representative.

(3) In reference to inspection, all works rejected by the Engineer’s Representative shall be repaired, corrected or replaced by Private Party to attain good workmanship, and conform to the consented Working Drawings and approved Specifications. Therefore, ample time shall be provided for inspection and, if there is any defective work re-inspection of the Engineer’s Representative shall be performed. In the event that the Private Party should fail to carry out necessary changes, then the Engineer’s Representative shall have the right to make its own arrangement.

4.0.2.3 Tools and Appliances

(1) Unless otherwise stipulated, the Private Party shall provide any pay for all tools and other facilities necessary for the execution and completion of the works.

(2) If at any time prior to commencement or during the progress of works, tools, equipment and materials, in the opinion of the Engineer’s Representative, appear to be insufficient, of inappropriate to secure the required quality of works or proper rate of progress, the Engineer’s Representative may order the Private Party to increase their efficiency, improve their character, augment their number or replace with new tools, equipment and materials as required.

4.0.2.4 Nameplates and Identifications

(1) All parts of the installation, which are of interest for its operation and maintenance, shall be provided with nameplates, tags or arrows, especially in enclosed areas, such as ceiling, shafts, and other places accessible for maintenance service.

4.0.2.5 Submittal of Data for Approval

(1) The Private Party shall submit to the Engineer's Representative complete information regarding details of materials and equipment involved, prior to any purchase or manufacturing operation. Any purchase or manufacturing operations carried out prior to obtaining such approval shall be at the Private Party's sole responsibility.

(2) Each equipment information shall be separately submitted by listing all the details and with attached catalogue indicating at least the model, series, size and performance. Such data shall be sufficient detail to enable the Engineer's Representative to identify that particular product and to form an opinion to its conformity to the Specification.

(3) The Private Party shall stamp the name of his company and sign all documents to be submitted for approval.

4.0.2.6 Approval of Materials

(1) Only new materials and equipment shall be incorporated in the Works. All materials and equipment furnished by the Private Party shall be subject to inspections and approval of the Engineer's Representative. The materials and equipment used for the Works shall correspond to the approved makes or other data. Any materials which, in the opinion of the Engineer's Representative, have lower quality than the approved makes shall promptly be removed from the job site.

(2) Whenever requested by the Engineer's Representative, the Private Party shall send materials to be tested by an independent institute selected by the Engineer's Representative.

(3) If these should be an unavoidable necessity to use materials and equipment that deviate from the specification or from approved samples, then the Private Party shall immediately inform the Engineer's Representative in writing and submit the substitute items of equal quality for approval.

4.0.2.7 Detailed Design Drawings

(1) The Private Party shall prepare detailed design drawings in accordance with the SRT's Requirements – Design, comprising complete details of items to be fabricated and works to be installed. These drawings shall be submitted to the Engineer's Representative for approval before proceeding the preparation of Working Drawing.

(2) Detailed design drawings shall be checked and signed by Registered engineer of the Private Party. All submitted drawings shall indicate the date of submission and the date(s) of revision(s).

(3) All detailed design drawings shall conform to "Outline Design Specification" and including design criteria and design calculation. The design criteria and design calculation shall be checked and signed by Registered Engineer and submitted to the Engineer's Representative for approval.

(4) Size and scale of the detailed design drawings shall be at least 1:100 scale except for enlarged scale details done for clarity, which shall be in conformity with international standards or as directed by the Engineer's Representative.

(5) Where required by the Engineer's Representative, the Private Party shall prepare additional drawings, diagrams, etc., which in the opinion of the Engineer's Representative are considered necessary for a proper execution of the Works.

(6) The approval of the Engineer's Representative never releases the Private Party from his responsibility or his liability regarding the exact dimensions and any further properties of the installations.

4.0.2.8 Working Drawings

(1) After detailed design drawings have been reviewed and approval by Engineer's Representative, the Private Party shall prepare Working Drawings comprising complete details of items to be fabricated and works to be installed. These

Working Drawings shall be submitted to the Engineer’s Representative for approval before installation.

(2) The drawings shall be checked by the Private Party for accuracy with regard to dimensions taken in the building(s) and shall closely follow manufacturer's recommendations. All submitted drawings shall be signed by the Private Party, and shall indicate the date of submission and the date(s) of revision(s).

(3) In case Working Drawings require modifications for whichever reason, the Private Party has to clearly identify the portion that was modified, and has to indicate the running number of revision every time that a revision-drawing is submitted.

(4) The installation detailed shall be checked with the building works, the structure and other related trades to prevent conflicts that may cause delay of the project.

(5) Size and scale of the Working Drawings shall be at least 1:100 scale except for enlarged scale details done for clarity, which shall be in conformity with international standards or as directed by the Engineer’s Representative.

(6) Where required by the Engineer’s Representative, the Private Party shall prepare additional drawings, diagrams, etc., which in the opinion of the Engineer’s Representative are considered necessary for a proper execution of the Works.

(7) The Private Party shall not proceed his work for a certain part or section, prior to the approval of the Working Drawings..

(8) Approval of the Working Drawings by the Engineer’s Representative shall not be construed as a complete check but will indicate only the general method of installation and its details are satisfactory.

(9) The approval of the Engineer’s Representative never releases the Private Party from his responsibility or his liability regarding the exact dimensions and any further properties of the installations.

(10) Working Drawings submitted without sufficient detailed shall be rejected and new submission shall be required.

4.0.2.9 As-Built Drawings

(1) The as-built drawings shall record all changes arising during the installation and detail all relevant data concerning makes, types, numbers, capacities, sized and quantities, etc.

(2) The Private Party shall submit to the Engineer's Representative 3 sets of prints and 1 set of reproducible drawings.

(3) The Private Party shall submit to the Engineer's Representative 3 sets of DVD or Portable Hard Disk that contained all PDF documents and AUTOCAD file same data as hard copy.

4.0.2.10 Transportation of Materials and Equipment

(1) The Private Party shall submit in advance a transportation schedule of materials to the Engineer's Representative and coordinate in preparing passage ways and storage facilities.

(2) The Private Party shall be responsible for all expense incurred during shipping and transporting of material and equipment to the job site. The materials and equipment shall be handled in a manner to prevent warping, twisting, bending, breaking, chipping, rusting and any injury, theft of damage or any kind what so ever.

(3) The shipping documents of particular materials and equipment shall be submitted to the Engineer's Representative as soon as the materials and equipment have arrived at the Site.

4.0.2.11 Materials and Equipment Storage

(1) The Private Party shall prepare storage areas of sufficient size for all necessary materials and equipment brought to the job site. The storage areas shall be provided with access for inspection and removal of the stored materials and equipment.

(2) Materials and equipment delivered to the Site without suitable storage shall not be accepted.

4.0.3 Execution

4.0.3.1 Temporary Power Supply and Others

(1) The Private Party shall connect electrical wires, telephone wires and water pipe for his own use at suitable connection points and shall bear the expense of usage, which shall be removed upon completion of sections of the Works.

4.0.3.2 Responsibility

(1) The Private Party shall establish, maintain, and supervise all precautions and programs for safety and provide protection to prevent damage, injury or loss to :

(a) All workmen on the worksite and other persons who may be affected thereby.

(b) All works and all materials or equipment to be incorporated herein, whether in storage on or off the site.

(2) As the work proceeds, the Private Party shall progressively remove rubbish and surplus materials away from the construction site and shall maintain his working area in a clean and tidy condition as far as is practicable.

(3) Upon completion of the Works he shall, without delay, remove all his temporary works and buildings, all tools, equipment and surplus materials, and shall clean the whole area affected by his work and leave it ready for immediately occupation.

(4) All materials, equipment and finished works shall be kept in good condition. The completed work shall be the Private Party's property until handed over to the Engineer's Representative.

4.0.3.3 Field Testing

(1) Test all fire protection equipment upon completion of installation to ensure that the equipment operates satisfactorily and to conform to Contract Documents.

(2) Field testing shall be required for all equipment furnished, installed or connected by the Private Party to assure proper installation, setting, connection, and functioning in accordance with the plans and specifications and manufacturer's recommendations.

(3) Testing shall be conducted in the presence of the Engineer’s Representative and, when necessary, under the supervision of equipment manufacturer's field engineer.

(4) All tests recommended by the equipment manufacturer whether specified in these Specifications or not, shall be included, unless specifically waived by the Engineer’s Representative.

(5) Testing shall include any additional tests issued by the Engineer’s Representative to determine that equipment, material and system meet requirements of the Specifications.

(6) The Private Party shall maintain in quadruplicate a written record of all tests showing date, personnel making test, equipment or material tested, tests performed and results. Two copies of test records shall be given to the Engineer’s Representative.

(7) Private Party shall be responsible for any damage to equipment or material due to improper test procedures or test apparatus handling, and shall replace or restore to original condition any damaged equipment or material.

(8) Safety devices such as rubber gloves and blankets, protective screens and barriers, danger signs, etc. shall be provided by the Private Party and shall be used to adequately protect and warn all personnel in the vicinity of the tests.

(9) The Private Party shall furnish all testing equipment, and furnish temporary power source of proper type for testing purposes when normal supply is not available at the time of testing.

(10) The conduit and wiring system, shall be checked to ensure that the system has been installed in such a way as to provide a safe and reliable system.

(11) Test all miscellaneous equipment furnished by equipment manufacturer as recommended by the manufacturer i.e., circuit breaker, low voltage switchboard, motor (if any) etc unless specifically waived by the Engineer's Representative.

(12) Include all additional tests issued by Engineer's Representative that he deems necessary because of field conditions, to determine that equipment and material and systems meet requirements of these Specifications.

(13) Be responsible for all damage to equipment or material due to improper test procedures or test apparatus handling.

4.0.3.4 Operation and Maintenance Instructions Manual

(1) The manual shall be prepared in hard cover building in sets to be submitted to the Engineer's Representative on acceptance of the completed work.

(a) Section 1 Comprises submittal data of all equipment and materials that have been approved.

(b) Section 2 Comprises catalogues, categorized in groups, complete with installation operations and the maintenance manuals from the manufacturers.

(c) Section 3 Comprises filled out test reports in the field.

(d) Section 4 Comprises spare parts list and recommended spare parts.

(e) Section 5 Comprises maintenance and services schedule, and service and maintenance procedures for individual equipment listed daily, weekly, monthly, quarterly and yearly.

(f) Section 6 Comprises system operation manual

(2) A draft copy of the manual shall be submitted to the Engineer's Representative for approval first.

4.0.3.5 Asset List

(1) General

(a) The Private Party shall produce an asset list of all main equipment. The SRT or Engineer's Representative have an option to include other accessories with consideration of availability on local market, high value and importance to operation.

(b) The Private Party is responsible for developing a data based information of the asset list or use of commercial software for asset management. Software operating system shall be Windows based (Windows 8) or as agreed with the SRT and the Engineer's Representative.

(c) The list data based shall be capable exported to Asset Management Software of the SRT.

(d) The list shall be submitted in conjunction to the Operation and Maintenance Instruction Manual to the SRT or Engineer's Representative for approval.

(2) Asset Data Based Requirement

The Private Party shall develop an asset list form and issued to the SRT and the Engineer's Representative for approval but shall contain information not limited to the following items:

(a) Asset number : Referring to tags installed in each equipment

(b) Equipment unit number

(c) Equipment description : Type and Capacity

(d) Manufacturer, Model number, Serial number, Date manufactured

(e) Expected service life

(f) Service warrantee Information : Start and expire date

(g) Manufacturer contact information

(h) Number of units

(i) Initial value of equipment

(j) Location : Name of building, room and area serve

(3) Asset Number

The Private Party shall install asset numbering labels on all equipment included in the list and shall be in accordance to the Specification stipulated in Equipment Identification and Labeling Section.

4.0.3.6 Works to Completion

(1) The Private Party shall commission, clean down, and leave in full working order the works as specified.

(2) As the installation proceeds the Private Party shall prepare record drawings of the Fire Protection installation, as built drawing. It will be sufficient to modify these contract drawings showing any amendments to the service which have taken place and submit the marked-up prints to the Engineer's Representative for approval.

(3) The Private Party shall deliver to the Engineer's Representative on completion of the works, manufacturer's literature, specifications, technical information and record drawings for all equipment installed.

4.1 DIESEL ENGINE FIRE PUMP

4.1.1 General

4.1.1.1 General Requirement

(1) The Private Party shall furnish and install the fire pump as shown on specified herein.

(2) All pumps used in the fire protection system shall be of one manufacturer.

4.1.1.2 Standard and Reference

Pumps shall comply with the following codes and standards.

(1) National Fire Protection Association (NFPA)

NFPA 20/2002 : Standard for the Installation of Centrifugal Fire Pumps

(2) Underwriters Laboratories, Inc. (UL)

UL 218	:	Fire Pump Controllers
UL 448	:	Pumps for Fire-Protection Service
UL 1008	:	Standard for Transfer Switch Equipment
UL 1478	:	Fire Pump Relief Valves

(3) American Society of Mechanical Engineers (ASTM)

ASTM A48	:	Standard Specification for Gray Iron Castings
ASTM A53	:	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A582	:	Standard Specification for Free-Machining Stainless Steel Bars
ASTM B584	:	Standard Specification for Copper Alloy Sand Castings for General Applications

(4) Factory Mutual (FM)

4.1.1.3 Submittals

(1) The Private Party shall submit pump performance curves, material lists and technical data for approval.

(2) The pump supplier shall submit certificate test of origin from manufacturer before the pump on site.

(3) The Private Party shall submit the following technical data for approval before installation:

(a) Dimension plan and elevation view drawing of the fire pump, required clearances, and location of all field piping and electrical connections.

(b) Diagram of control system indicated points for field interface and field connection.

(c) Installation and operation manuals.

4.1.1.4 Warranty

(1) All part of the fire pump shall guaranteed by the manufacture and/or by the Private Party at least two (2) yeas after handover.

4.1.2 Materials

4.1.2.1 Description

(1) Pumps shall furnish not less than 150 percent of rated capacity at a total head of not less than 65 percent of the total rated head. The total shutoff head shall not exceed 140 percent of the total rated head on pumps.

(2) Pumps shall be selected for a total efficiency of not less than 70 percent.

(3) Pumps shall be UL 448 Listed and/or FM approved.

(4) The pump type shall be specified as specified herein. General Classification type shall be as the following.

(a) Horizontal Split Case Centrifugal Type

Pumps shall be of the non-overloading, centrifugal, volute type. They shall be of the horizontally split, double suction type with suction and discharge connections in the lower half of the casing, allowing removal of the rotating element without disturbing pipe connections.

(b) Vertical Multi-Stage Turbine Type

Fire Pumps shall be of the vertical water lubricated multi-stage turbine type. Each unit shall include a bowl assembly, strainer, column and shaft, surface discharge head, vertical hollow shaft, right angle gear and flexible gear engine shaft, automatic air release and pressure gauge.

4.1.2.2 Component

(1) Horizontal Split Case Centrifugal Pumps

(a) Casing

Casing of horizontally split pumps shall be designed for a working pressure of 15 kg/cm2 (225 psig) or 1 3/4 times the actual discharge pressure, whichever is greater. Pressure classification of flange connections shall correspond to casing working pressure. Casing material shall be cast-iron, precision manufactured for best performance and long-term duty. Water discharge diffusers shall be included to reduce radial torques to impellers.

(b) Wearing Ring

Wearing rings shall be suitable for an individual application. Rings shall be replaceable, and positively keyed to prevent rotation

(c) Impeller

Impellers shall be one piece, cast-bronze and dynamically balanced. Impellers of pumps shall be fully enclosed and hydraulically balance. Impellers shall be accurately keyed to the shaft and fixed in an axial position by shaft sleeves and separate snap rings. Impellers shall be fully protected against damage from reverse rotation.

(d) Shaft

Shafts for pumps with stuffing boxes shall be of stainless steel, or steel SAE 1045 extending through the stuffing boxes. Where stuffing boxes are used, shafts shall be provided with water slingers. Shafts shall be provided with water slingers. Shafts shall be designed with high safety precautions to easily withstand the torsion loads with other stresses to which they may be subjected. They shall be so designed that there will be no detrimental vibration stresses. All shaft threading shall be external stresses. All shaft threading shall be external to the water passage and stuffing boxes. Shaft sleeves shall be keyed to the shafts and extended through the stuffing boxes. O-rings or gaskets shall be provided at sleeve ends to protect the shafts from water corrosion. They shall be so designed that no dismantling of the pump casings is required to replace the sleeves.

(e) Bearing

Bearing shall be heavy-duty ball bearing with a minimum average life of 100,000 hours. The bearing shall be self-sealed, and housed in malleable-iron housings aligned to a bearing bracket by means of large precision registers. Bearings shall be removable without dismantling any rotating elements or pumps.

(f) Stuffing Boxes

Stuffing boxes shall be deep enough for not less than 4 rings of packing and shall have bronze glands. Packing shall be suitable in all cases for the service required with proper consideration of water pressure, temperature, temperature changes and sediments carried in the water.

(g) Couplings

Pumps shall be provided with urethane flexible couplings with a service factor of at least 1.5 for an individual application. Couplings shall impose no restriction on normal end play or expansion. Suitable coupling guards shall also be provided.

(h) Base Plate

Pumps shall be provided with a cast-iron or fabricated steel base plate to hold both the pump and the motor in correct alignment. Pumps and motors shall be accurately aligned.

(i) Miscellaneous Fittings

High points of pump casings shall be provided with air vent cocks. Low points of casings shall be provided with valve drains and both inlet and outlet connection with properly located gauge tapping.

Casing brackets of pumps equipped with stuffing boxes shall be arranged to form drip pockets. A drip pipe shall be run from each drip pockets. A drip pipe shall be run from each drip pocket to the nearest drip funnel or floor drain.

(j) Circulation Relief Valve

Each pump shall be provided with a 20 mm. Φ (3/4 inch) circulation valve for pump overheat protection. Furthermore, Relief valves for over pressure protection shall be provided with sizes conforming to Table 2.20 in NFPA 20/2002. Relief water pipes shall terminate at the fire reservoir.

(k) Pressure Switch

Switches shall be used for pump control and shall be able to withstand 28 kg/cm2 (400 psig) working pressure without any damage.

(l) Anti-Vibration

Each pump shall be mounted on approved vibration isolators which are, In turn, placed on a concrete base. The isolators shall be selected and installed in accordance with the manufacturer's recommendation such that no disturbing vibration and noise is being transmitted to the nearby structure.

(2) Vertical Multi-Stage Turbine Pumps

(a) Bowl

The intermediate bowls, suction bell, and discharge bowl shall be flanged type constructed of close grained cast iron, and shall conform to ASTM designation A48, class 30. They shall be free from sand holes, blowholes, or other faults and must be accurately machined and fitted to close tolerance. The intermediate bowls shall have enamel or epoxy lined waterways for maximum efficiency and wear protection. All intermediate bowls shall be of identical design for interchangeability. A discharge bowl shall be used to connect bowls to the discharge column.

(b) Impellers

The impellers shall be constructed from ASTM B584 Silicon Brass or Silica Bronze and shall be the enclosed type. They shall be from defects and must be accurately cast, machined for optimum performance and minimum vibration. Impellers are to be balance to grade G6.3 of ISO 1940 as minimum. They shall be securely fastened to the bowl shaft with taper locks steel or split thrust ring of SS. The impeller running position shall be adjustable by shaft adjusting nut in the discharge head or on top of the hollow shaft driver.

(c) Suction

The suction bell shall be provided with non-soluble grease packed bronze bearing and a bronze sand collar shall be incorporated in the pump design to protect this bearing from abrasives. The bearing housing shall have sufficient opening at the bottom for removal of the bearing. A bronze basket type strainer shall be attached to the suction bell. It shall have a free area of at least four times the flow area of the suction connection size and the opening shall be sized to restrict the passage of 15 mm. (1/2") solids.

(d) Wearing Ring

Bowl assembly shall be fitted with replaceable wearing ring of aluminum bronze material in the suction bowl and intermediate bowls. Wearing rings shall have the mating cylindrical surface of the impeller to provide adequate sealing independent of vertical positioning of the impellers.

(e) Shaft

The bowl shaft and head shaft shall be constructed from ASTM A582 type 416 stainless steel. It shall be precision turned and ground with surface finish better than 40 RMS and shall be supported by water lubricated bearings of bronze alloy.

(f) Column Pipe

The column pipe shall be furnished in sections not exceeding a normal length of 3 m. (10 ft) and shall be connected by threaded-sleeve couplings or flanges. The length of top and bottom sections shall not be more than 1.5 m. (5 ft.) It shall be of ASTM A53 grade A steel pipe and the weight shall be not less than schedule 30. The threaded pipe shall be with 8 threads per inch with 5 mm. (3/16") taper per foot thread and faced parallel to butt against the centering spiders to from accurate alignment. All column flange faces shall be parallel and machined for rabbet fit to permit accurate alignment. The inside diameter of the pipe shall be such that the head losses shall not more than 5 meters per 100 meters of pipe.

(g) Lineshaft

The lineshaft shall be furnished in interchangeable section not over ten feet in length, and shall be couplings machined from solid steel bar. It shall have left- hand thread to tighten during pump operation. The diameter of the shaft shall be based on a combined shear stress of not more than 18% of the ultimate strength or not excess of 30% of the elastic limit in tension of the shafting material. The coupling shall be designed with higher safety factor than shaft. Lineshaft and coupling shall be of type 416 stainless steel. Centering spiders shall be furnished at each column pipe joint for shaft stabilization. Bearings shall be rubber sbr.

(h) Discharge Head

It shall be of the high profile type to allow shaft coupled above stuffing box and provided for mounting the driver and support the column and bowl assemblies it shall be high-grade cast iron, ASTM A48 Class 30B, or fabricated steel. The above ground outlet shall be flanged. It shall have a 15 mm. (1/2") NPT connection for a pressure gauge.

(i) Stuffing Box

The stuffing box shall be cast iron and shall contain a minimum of five rings of packing with lantern ring. It shall have a pressure relief connection. The packing gland shall be aluminum bronze split type secured in place with non-corrosive studs and nuts. The bearing shall be bronze. A rubber slinger shall be secured to the shaft above the packing gland.

(j) Bearing

Stuffing box bearing and inter bowl bearing shall be bronze ASTM B584. Line shaft bearing shall be rubber sbr.

(3) Diesel Engines

The engine brake horse power shall be rated at least 1.10 times the maximum power required. The engine shall be rated at standard SAE conditions for (152.4 meters above sea level and 0.746 meters HG (at 29.4 °C) by the testing laboratory. The engine shall be of a reputable manufacturer form which spare parts can be obtained easily.

(a) Governor

The engine shall be provided with an adjustable governor capable of regulating engine speed within a range of 10 percent between shut-off and maximum load conditions of the pump. The governor shall be set to maintain the rated pump speed at maximum pump load.

(b) Overspeed Shut-Down Device

The device shall be arranged such that the engine is shut-down at a speed approximately 20 percent above the rated engine speed, and that it can be manually reset.

The position of the overspeed shut-down device shall be indicated at the controller and will continue to show an overspeed trouble signal until the device is manually reset to normal operating position.

(c) Tachometer

A tachometer shall be provided to indicate revolutions per minute of the engine. An hour meter shall be provided to record total time of engine operation.

(d) Oil Pressure Gauges

The engine shall be provided with oil pressure gauges indicating lubricating oil pressure.

(e) Temperature Gauge

The engine shall be provided with a temperature gauge to indicate cooling water temperature.

(f) Instrument Panel

All engine instruments shall be placed on a suitable panel secured to the engine at a suitable point, both to the Architect approval.

(g) Automatic Controller Wiring

All connecting wires for automatic controllers shall be hardness or flexibly enclosed, mounted on the engine and connected in an engine junction box to terminals numbered to correspond with numbered terminals in the controller, for ready wiring in the field between the two sets of terminals.

(h) Battery and Charger

The engine shall be provided with two storage battery units, each having sufficient capacity, at 5°C, to maintain cranking speed recommended by the engine manufacturer through a 6 minute cycle (15 second cranking and 15 second rest, in 12 consecutive cycles).

The battery charger shall be suitable for use on a 220V, 50 Hz single phase supply and is to automatically maintain the 24 V batteries in a state approximate to full charge.

The battery shall be sealed lead-acid type having expected life time at least 10 years with 5 years product warranty.

(i) Signal for Engine Running and Crank Termination

The engine shall be provided with a speed sensitive switch to signal engine running and crank termination. Power for these signals shall be taken from a source other than the engine generator.

(j) Cooling System

A completely closed circuit cooling waste circulation system shall be provided.

(k) Engine Exhaust Pipe

The exhaust pipe shall be galvanized steel sized in accordance with the manufacturer's recommendations. This exhaust pipe shall be as short as possible and shall not exceed 4.5 m. in length, unless than one pipe size for each 1.5 m. in excess length. The exhaust pipe shall be insulated with 40 mm. of preformed fiberglass with aluminum jacket.

Stainless steel flexible connection shall be made between the engine exhaust outlet and the exhaust pipe.

(l) Fuel Tank

The tank shall be fabricated from at least 3 mm. steel sheet and shall hold enough storage for an 8 hour operation of the pump. The tank shall be installed above ground in a location approved by the Architect and equipped with fuel piping, drain, air vent and sight-glass.

(4) Controller

The controller shall be UL listed and/or FM approved completely assembled and wired from the factory the following items shall be included:

(a) Pressure switch or Pressure Transducer

(b) Weekly test program timer

(c) Automatic test run program

(d) Solid state crank cycle control

(e) Battery charger

(f) Pressure recorder

(g) Stop button

(h) Reset button

(i) Ammeter, Voltmeter

(j) Alarm devices such as for oil pressure, low fuel level, water temperature, failure to start, overspeed, battery no. 2 failure, charge loss and water storage tank low level.

(k) Other standard control accessories such as relays, pilot lamps, fuses, pushbuttons and alarm bell.

(l) Selector switch "AUTO-OFF-MANUAL"

4.1.3 Execution

4.1.3.1 Installation

(1) Install equipment in accordance with manufacturer's instructions.

(2) The Private Party shall align the pump and engine shafts to within the manufacturer's recommended tolerances prior to system start-up.

4.1.3.2 Testing and Commissioning

(1) General

All hydrostatic tests, flushing and field acceptance test procedures outlined in Chapter 11 Acceptance Testing, Performance, and Maintenance of NFPA 20/2002, shall be carried out.

(2) Hydrostatic Tests and Flushing

(a) Suction and discharge piping shall be hydrostatically tested at not less than 13.8 kg/cm^2 (200 psi) pressure, or at 3.4 kg/cm^2 (50 psi) in excess of the maximum pressure to be maintained in the system, whichever is greater. The pressure shall be maintained for 2 hours.

(b) Suction piping shall be flushed at a flow rate not less than indicated in tables or at the hydraulically calculated water demand rate of the system, whichever is greater.

Pipe Size	Flow Rate	
(mm.)	gpm	L/min
100	590	2,233
125	920	3,482
150	1,360	5,148
200	2,350	8,895
250	3,670	13,891
300	5,290	20,023

Flow Rate for Stationary Pumps

Pipe Size (in.)	Flow (gpm)
40	100
50	250
75	400
100	450
150	500

Flush Rate for Suction Piping

(c) The installing Private Party shall furnish a certificate of test prior to the start of the fire pump field acceptance test.

(3) Field Acceptance Tests

(a) All electric wiring to the fire pump motors, including control (multiple pumps) inter-wiring, emergency power supply, and jockey pump, shall be completed and checked by the electrical Private Party prior to the initial startup and acceptance test.

(b) A copy of the manufacturer's certified pump test characteristic curve shall be available for comparison of results of field acceptance test. The fire pump as installed shall equal the performance as indicated on the manufacturer's certified shop test characteristic curve within the accuracy limits of the test equipment.

(c) The fire pump shall perform at minimum, rated, and peak loads without objectionable overheating of any component.

(d) Vibrations of the fire pump assembly shall not be of a magnitude to warrant potential damage to any fire pump component.

(e) Emergency governor valve for steam shall be operated to demonstrate satisfactory performance of the assembly. Hand tripping shall be acceptable.

(f) Both local and remote alarm conditions shall be simulated to demonstrate satisfactory operation.

(g) The fire pump or foam concentrate pump shall be in operation for not less than 1 hour total time during all of the foregoing tests.

(4) Field Acceptance Test Procedures

(a) Test Equipment

Test equipment shall be provided to determine net pump pressures, rate of flow through the pump, volts and amperes for electric motor-driven pumps, and speed.

(b) Flow Tests

(i) The minimum, rated, and peak loads of the fire pump shall be determined by controlling the quantity of water discharged through approved test devices

(ii) The pump flow for positive displacement pumps shall be tested and determined to meet the specified rated performance criteria. One performance point is required to establish positive displacement pump acceptability.

(c) Measurement Procedure

(i) General

The quantity of water discharging from the fire pump assembly shall be determined and stabilized. Immediately thereafter, the operating conditions of the fire pump and driver shall be measured. Foam concentrate pumps shall be permitted to be tested with water; however, water flow rates can be lower than expected foam flow rates because of viscosity.

(ii) The pump flow test for positive displacement pumps shall be accomplished using a flowmeter or orifice plate installed in a test loop back to the foam concentrate tank or the inlet side of a water pump. The flowmeter reading or discharge pressure shall be recorded and shall be in accordance with the pump manufacturer’s flow performance data. If orifice plates are used, the orifice size and corresponding discharge pressure to be maintained on the upstream side of the orifice plate shall be made available to the authority having jurisdiction. Flow rates shall be as specified while operating at the system design pressure.

(iii) For electric motors operating at rated voltage and frequency, the ampere demand shall not exceed the product of a full-load ampere rating times the allowable service factor as stamped on the motor nameplate

(iv) For electric motors operating under varying voltage, the product of the actual voltage and current demand shall not exceed the product of the rated voltage and rated full-load current times the allowable service factor. The voltage at the motor shall not vary more than 5 percent below or 10 percent above rated (nameplate) voltage during the test.

(v) Engine-driven units shall not show signs of overload or stress. The governor of such units shall be set at the time of the test to properly regulate the engine speed at rated pump speed.

(vi) The gear drive assembly shall operate without excessive objectionable noise, vibration, or heating.

(d) Loads Start Test

The fire pump unit shall be started and brought up to rated speed without interruption under the conditions of a discharge equal to peak load.

(e) Phase Reversal Test

For electric motors, a test shall be performed to ensure that there is not a phase reversal condition in either the normal power supply configuration or from the alternate power supply (where provided).

(5) Controller Acceptance Test

(a) Fire pump controllers shall be tested in accordance with the manufacturer's recommended test procedure. As a minimum, no less than six automatic and six manual operations shall be performed during the acceptance test.

(b) A fire pump driver shall be operated for a period of at least 5 minutes at full speed during each of the operations.

(c) The automatic operation sequence of the controller shall start the pump from all provided starting features. This sequence shall include pressure switches or remote starting signals.

(d) Tests of engine-driven controllers shall be divided between both sets of batteries.

(e) The selection, size, and setting of all overcurrent protective devices, including fire pump controller circuit breaker, shall be confirmed to be in accordance with this standard.

(f) The fire pump shall be started once from each power service and run for a minimum of 5 minutes.

4.2 ELECTRIC FIRE PUMP

4.2.1 General

4.2.1.1 General Requirement

(1) The Private Party shall furnish and install the fire pump as shown on specified herein.

(2) All pumps used in the fire protection system shall be of one manufacturer.

4.2.1.2 Standard and Reference

Pumps shall comply with the following codes and standards.

(1) National Fire Protection Association (NFPA)

NFPA 20/2002 : Standard for the Installation of Centrifugal Fire Pumps

(2) Underwriters Laboratories, Inc. (UL)

UL 218	:	Fire Pump Controllers
UL 448	:	Pumps for Fire-Protection Service
UL 1008	:	Standard for Transfer Switch Equipment
UL 1478	:	Fire Pump Relief Valves

(3) American Society of Mechanical Engineers (ASTM)

ASTM A48	:	Standard Specification for Gray Iron Castings
ASTM A53	:	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A582	:	Standard Specification for Free-Machining Stainless Steel Bars
ASTM B584	:	Standard Specification for Copper Alloy Sand Castings for General Applications

(4) Factory Mutual (FM)

4.2.1.3 Submittals

(1) Pump performance curves shall be submitted for approval together with the pump technical data.

(2) The pump supplier shall submit certificate test of origin from manufacturer before the pump on site.

(3) The Private Party shall submit the following technical data for approval before installation:

(a) Dimension plan and elevation view drawing of the fire pump, required clearances, and location of all field piping and electrical connections.

(b) Diagram of control system indicated points for field interface and field connection.

(c) Installation and operation manuals.

4.2.1.4 Warranty

(1) All part of the fire pump shall guaranteed by the manufacture and/or by the Private Party at least two (2) years after handover.

4.2.2 Materials

4.2.2.1 Description

(1) Pumps shall furnish not less than 150 percent of rated capacity at a total head of not less than 65 percent of the total rated head. The total shutoff head shall not exceed 140 percent of the total rated head on pumps.

(2) Pumps shall be selected for a total efficiency of not less than 70 percent.

(3) Pumps shall be UL 448 Listed and/or FM approved.

(4) The pump type shall be specified as shown on specified herein. General Classification type shall be as the following.

(a) Horizontal Split Case Centrifugal Type

Pumps shall be of the non-overloading, centrifugal, volute type. They shall be of the horizontally split, double suction type with suction and discharge connections in the lower half of the casing, allowing removal of the rotating element without disturbing pipe connections.

(b) Vertical Multi-Stage Turbine Type

Fire Pumps shall be of the vertical water lubricated multi-stage turbine type. Each unit shall include a bowl assembly, strainer, column and shaft, surface discharge head, vertical hollow shaft, right angle gear and flexible gear engine shaft, automatic air release and pressure gauge.

4.2.2.2 Component

(1) Horizontal Split Case Centrifugal Pumps

(a) Casing

Casing of horizontally split pumps shall be designed for a working pressure of 15 kg/cm2 (225 psig) or 1 3/4 times the actual discharge pressure, whichever is greater. Pressure classification of flange connections shall correspond to casing working pressure. Casing material shall be cast-iron, precision manufactured for best performance and long-term duty. Water discharge diffusers shall be included to reduce radial torques to impellers.

(b) Wearing Ring

Wearing rings shall be suitable for an individual application. Rings shall be replaceable, and positively keyed to prevent rotation.

(c) Impeller

Impellers shall be one piece, cast-bronze and dynamically balanced. Impellers of pumps shall be fully enclosed and hydraulically balance. Impellers shall be accurately keyed to the shaft and fixed in an axial position by shaft sleeves and separate snap rings. Impellers shall be fully protected against damage from reverse rotation.

(d) Shaft

Shafts for pumps with stuffing boxes shall be of stainless steel, or steel SAE 1045 nickel-iron extending through the stuffing boxes. Where stuffing boxes are used, shafts shall be provided with water slingers. Shafts shall be provided with water slingers. Shafts shall be designed with high safety precautions to easily withstand the torsion loads with other stresses to which they may be subjected. They shall be so designed that there will be no detrimental vibration stresses. All shaft threading shall be external stresses. All shaft threading shall be external to the water passage and stuffing boxes. Shaft sleeves shall be keyed to the shafts and extended through the stuffing boxes. O-rings or gaskets shall be provided at sleeve ends to protect the shafts from water corrosion. They shall be so designed that no dismantling of the pump casings is required to replace the sleeves.

(e) Bearing

Bearing shall be heavy-duty ball bearing with a minimum average life of 100,000 hours. The bearing shall be self-sealed, and housed in malleable-iron housings aligned to a bearing bracket by means of large precision registers. Bearings shall be removable without dismantling any rotating elements or pumps.

(f) Stuffing Boxes

Stuffing boxes shall be deep enough for not less than 4 rings of packing and shall have bronze glands. Packing shall be suitable in all cases for the service required with proper consideration of water pressure, temperature, temperature changes and sediments carried in the water.

(g) Couplings

Pumps shall be provided with urethane flexible couplings with a service factor of at least 1.5 for an individual application. Couplings shall impose no restriction on normal end play or expansion. Suitable coupling guards shall also be provided.

(h) Base Plate

Pumps shall be provided with a cast-iron or fabricated steel base plate to hold both the pump and the motor in correct alignment. Pumps and motors shall be accurately aligned.

(i) Miscellaneous Fittings

High points of pump casings shall be provided with air vent cocks. Low points of casings shall be provided with valve drains and both inlet and outlet connection with properly located gauge tapping.

Casing brackets of pumps equipped with stuffing boxes shall be arranged to form drip pockets. A drip pipe shall be run from each drip pockets. A drip pipe shall be run from each drip pocket to the nearest drip funnel or floor drain.

(j) Circulation Relief Valve

Each pump shall be provided with a 20 mm. Φ (3/4 inch) circulation valve for pump overheat protection. Furthermore, Relief valves for over pressure protection shall be provided with sizes conforming to Table 2.20 in NFPA 20/2002. Relief water pipes shall terminate at the fire reservoir.

(k) Pressure Switch

Switches shall be used for pump control and shall be able to withstand 28 kg/cm2 (400 psig) working pressure without any damage.

(l) Anti-Vibration

Each pump shall be mounted on approved vibration isolators which are, In turn, placed on a concrete base. The isolators shall be selected and installed in accordance with the manufacturer's recommendation such that no disturbing vibration and noise is being transmitted to the nearby structure.

(2) Vertical Multi-Stage Turbine Pumps

(a) Bowl

The intermediate bowls, suction bell, and discharge bowl shall be flanged type constructed of close grained cast iron, and shall conform to ASTM designation A48, class 30. They shall be free from sand holes, blowholes, or other faults and must be accurately machined and fitted to close tolerance. The intermediate bowls shall have enamel or epoxy lined waterways for maximum efficiency and wear protection. All intermediate bowls shall be of identical design for interchangeability. A discharge bowl shall be used to connect bowls to the discharge column.

(b) Impellers

The impellers shall be constructed from ASTM B584 Silicon Brass or Silicon Bronze and shall be the enclosed type. They shall be from defects and must be accurately cast, machined for optimum performance and minimum vibration. Impellers are to be balance to grade G6.3 of ISO 1940 as minimum. They shall be securely fastened to the bowl shaft with taper locks steel and split thrust ring of SS. The impeller running position shall be adjustable by shaft adjusting nut in the discharge head or on top of the hollow shaft driver.

(c) Suction

The suction bell shall be provided with non-soluble grease packed bronze bearing and a bronze sand collar shall be incorporated in the pump design to protect this bearing from abrasives. The bearing housing shall have sufficient opening at the bottom for removal of the bearing. A bronze basket type strainer shall be attached to the suction bell. It shall have a free area of at least four times the flow area of the suction connection size and the opening shall be sized to restrict the passage of 15 mm. (1/2") solids.

(d) Wearing Ring

Bowl assembly shall be fitted with replaceable wearing ring of aluminum bronze material in the suction bowl and intermediate bowls. Wearing rings shall have the mating cylindrical surface of the impeller to provide adequate sealing independent of vertical positioning of the impellers.

(e) Shaft

The bowl shaft and head shaft shall be constructed from ASTM A582 type 416 stainless steel. It shall be precision turned and ground with surface finish better than 40 RMS and shall be supported by water lubricated bearings of bronze alloy.

(f) Column Pipe

The column pipe shall be furnished in sections not exceeding a normal length of 3 m. (10 ft) and shall be connected by threaded-sleeve couplings or flanges. The length of top and bottom sections shall not be more than 1.5 m. (5 ft.) It shall be of ASTM A53 grade A steel pipe and the weight shall be not less than schedule 30. The threaded pipe shall be with 8 threads per inch with 5 mm. (3/16") taper per foot thread and faced parallel to butt against the centering spiders to from accurate alignment. All column flange faces shall be parallel and machined for rabbet fit to permit accurate alignment. The inside diameter of the pipe shall be such that the head losses shall not more than 5 meters per 100 meters of pipe.

(g) Lineshaft

The lineshaft shall be furnished in interchangeable section not over ten feet in length, and shall be couplings machined from solid steel bar. It shall have left- hand thread to tighten during pump operation. The diameter of the shaft shall be based on a combined shear stress of not more than 18% of the ultimate strength or not excess of 30% of the elastic limit in tension of the shafting material. The coupling shall be designed with higher safety factor than shaft. Lineshaft and coupling shall be of type 416 stainless steel. Centering spiders shall be furnished at each column pipe joint for shaft stabilization. Bearings shall be rubber.

(h) Discharge Head

It shall be of the high profile type to allow shaft coupled above stuffing box and provided for mounting the driver and support the column and bowl assemblies it shall be high-grade cast iron, ASTM A48 Class 30B, or fabricated steel. The above ground outlet shall be flanged. It shall have a 15 mm. (1/2") NPT connection for a pressure gauge.

(i) Stuffing Box

The stuffing box shall be cast iron and shall contain a minimum of five rings of packing with lantern ring. It shall have a pressure relief connection. The packing gland shall be aluminum bronze split type secured in place with non-corrosive studs and nuts. The bearing shall be bronze. A rubber slinger shall be secured to the shaft above the packing gland.

(j) Bearing

Stuffing box bearing and inter bowl bearing shall be bronze ASTM B584. Line shaft bearing shall be rubber sbr.

(3) Motor

Each pump shall be driven not over 1,500 rpm, 380V/3PH/50Hz totally enclosed fan-cooled Class F insulation motor. The rated HP shall be at least 1.15 times the maximum power required.

(4) Controller

The controller shall be UL listed and/or FM approved completely assembled and wired from the factory the following items shall be included:

(a) Pressure switch or Pressure Transducer

(b) Weekly test program timer

(c) Automatic test run program

(d) Solid state crank cycle control

(e) Battery charger

(f) Pressure recorder

(g) Stop button

(h) Reset button

(i) Ammeter, Voltmeter

(j) Alarm devices such as for oil pressure, low fuel level, water temperature, failure to start, overspeed, battery no. 2 failure, charge loss and water storage tank low level.

(k) Other standard control accessories such as relays, pilot lamps, fuses, pushbuttons and alarm bell.

(l) Selector switch "AUTO-OFF-MANUAL"

4.2.3 Execution

4.2.3.1 Installation

(1) Install equipment in accordance with manufacturer’s instructions.

(2) The Private Party shall align the pump and engine shafts to within the manufacturer’s recommended tolerances prior to system start-up.

4.2.3.2 Testing and Commissioning

(1) General

All hydrostatic tests, flushing and field acceptance test procedures outlined in Chapter 11 Acceptance Testing, Performance, and Maintenance of NFPA 20/2002, shall be carried out.

(2) Hydrostatic Tests and Flushing

(a) Suction and discharge piping shall be hydrostatically tested at not less than 13.8 kg/cm2 (200 psi) pressure, or at 3.4 kg/cm2 (50 psi) in excess of the maximum pressure to be maintained in the system, whichever is greater. The pressure shall be maintained for 2 hours.

(b) Suction piping shall be flushed at a flow rate not less than indicated in tables or at the hydraulically calculated water demand rate of the system, whichever is greater.

Pipe Size	Flow Rate	
(mm.)	gpm	L/min
100	590	2,233
125	920	3,482
150	1,360	5,148
200	2,350	8,895
250	3,670	13,891
300	5,290	20,023

Flow Rate for Stationary Pumps

Pipe Size (in.)	Flow (gpm)
40	100
50	250
75	400
100	450
150	500

Flush Rate for Suction Piping

(c) The installing Private Party shall furnish a certificate of test prior to the start of the fire pump field acceptance test.

(3) Field Acceptance Tests

(a) All electric wiring to the fire pump motors, including control (multiple pumps) inter-wiring, emergency power supply, and jockey pump, shall be completed and checked by the electrical Private Party prior to the initial startup and acceptance test.

(b) A copy of the manufacturer's certified pump test characteristic curve shall be available for comparison of results of field acceptance test. The fire pump as installed shall equal the performance as indicated on the manufacturer's certified shop test characteristic curve within the accuracy limits of the test equipment.

(c) The fire pump shall perform at minimum, rated, and peak loads without objectionable overheating of any component.

(d) Vibrations of the fire pump assembly shall not be of a magnitude to warrant potential damage to any fire pump component.

(e) Emergency governor valve for steam shall be operated to demonstrate satisfactory performance of the assembly. Hand tripping shall be acceptable.

(f) Both local and remote alarm conditions shall be simulated to demonstrate satisfactory operation.

(g) The fire pump or foam concentrate pump shall be in operation for not less than 1 hour total time during all of the foregoing tests.

(4) Field Acceptance Test Procedures

(a) Test Equipment

Test equipment shall be provided to determine net pump pressures, rate of flow through the pump, volts and amperes for electric motor-driven pumps, and speed.

(b) Flow Tests

(i) The minimum, rated, and peak loads of the fire pump shall be determined by controlling the quantity of water discharged through approved test devices

(ii) The pump flow for positive displacement pumps shall be tested and determined to meet the specified rated performance criteria. One performance point is required to establish positive displacement pump acceptability.

(c) Measurement Procedure

(i) General

The quantity of water discharging from the fire pump assembly shall be determined and stabilized. Immediately thereafter, the operating conditions of the fire pump and driver shall be measured. Foam concentrate pumps shall be permitted to be tested with water; however, water flow rates can be lower than expected foam flow rates because of viscosity.

(ii) The pump flow test for positive displacement pumps shall be accomplished using a flowmeter or orifice plate installed in a test loop back to the foam concentrate tank or the inlet side of a water pump. The flowmeter reading or discharge pressure shall be recorded and shall be in accordance with the pump manufacturer's flow performance data. If orifice plates are used, the orifice size and corresponding discharge pressure to be maintained on the upstream side of the orifice plate shall be made available to the authority having jurisdiction. Flow rates shall be as specified while operating at the system design pressure.

(iii) For electric motors operating at rated voltage and frequency, the ampere demand shall not exceed the product of a full-load ampere rating times the allowable service factor as stamped on the motor nameplate

(iv) For electric motors operating under varying voltage, the product of the actual voltage and current demand shall not exceed the product of the rated voltage and rated full-load current times the allowable service factor. The voltage at the motor shall not vary more than 5 percent below or 10 percent above rated (nameplate) voltage during the test.

(v) Engine-driven units shall not show signs of overload or stress. The governor of such units shall be set at the time of the test to properly regulate the engine speed at rated pump speed.

(vi) The gear drive assembly shall operate without excessive objectionable noise, vibration, or heating.

(d) Loads Start Test

The fire pump unit shall be started and brought up to rated speed without interruption under the conditions of a discharge equal to peak load.

(e) Phase Reversal Test

For electric motors, a test shall be performed to ensure that there is not a phase reversal condition in either the normal power supply configuration or from the alternate power supply (where provided).

(5) Controller Acceptance Test

(a) Fire pump controllers shall be tested in accordance with the manufacturer's recommended test procedure. As a minimum, no less than six automatic and six manual operations shall be performed during the acceptance test.

(b) A fire pump driver shall be operated for a period of at least 5 minutes at full speed during each of the operations.

(c) The automatic operation sequence of the controller shall start the pump from all provided starting features. This sequence shall include pressure switches or remote starting signals.

(d) Tests of engine-driven controllers shall be divided between both sets of batteries.

(e) The selection, size, and setting of all overcurrent protective devices, including fire pump controller circuit breaker, shall be confirmed to be in accordance with this standard.

(f) The fire pump shall be started once from each power service and run for a minimum of 5 minutes.

4.3 JOCKEY PUMP

4.3.1 General

4.3.1.1 General Requirement

(1) The Private Party shall furnish and install the fire pump as shown on specified herein.

4.3.1.2 Standard and Reference

Pumps shall comply with the following codes and standards.

(1) National Fire Protection Association (NFPA)

NFPA 20/2002	:	Standard for the Installation of Centrifugal Fire Pumps

(2) Underwriters Laboratories, Inc. (UL)

UL 218	:	Fire Pump Controllers
UL 448	:	Pumps for Fire-Protection Service
UL 1008	:	Standard for Transfer Switch Equipment

(3) Factory Mutual (FM)

4.3.1.3 Submittals

(1) Pump performance curves shall be submitted for approval together with the pump technical data.

(2) The pump supplier shall submit certificate test of origin from manufacturer before the pump on site.

(3) The Private Party shall submit the following technical data for approval before installation:

(a) Dimension plan and elevation view drawing of the fire pump, required clearances, and location of all field piping and electrical connections.

(b) Diagram of control system indicated points for field interface and field connection.

(c) Installation and operation manuals.

4.3.1.4 Warranty

(1) All part of the fire pump shall guaranteed by the manufacture and/or by the Private Party at least two (2) years after handover.

4.3.2 Materials

4.3.2.1 Description

Pumps shall be regenerative turbine pumps with suction arrangement suitable for suction of water from the water reservoir.

4.3.2.2 Component

(1) Motors

Each pump shall be driven by a 2,900 rpm, 380V/3 Ø /50 Hz totally enclosed fan-cooled class B insulation motor. The rated Hp shall be at least 1.15 times the maximum power required.

(2) Casings

Casings of jockey pumps shall be designed for a working pressure of 20 kg/cm2 or 1.5 times the actual discharge pressure, whichever is greater. Casing material shall be cast-iron, precision manufactured for best performance and long-term duty. Specification for wearing rings, impellers, shafts, bearings, stuffing box couplings, base-plates, circulation relief valves, anti-vibration pads differential pressure switches shall be similar to the fire pump specification.

(3) Controller

The controller shall be UL listed or FM approved, completely assembled and wired from the factory.

The following items shall be included:

(a) Isolating switch

(b) Circuit breaker

(c) Direction line motor starter with overload relay and external reset.

(d) Pressure switch

(e) Other standard control accessories such as relays, pilot lamps, fuses and pushbuttons.

(f) Minimum running timer

4.3.3 Execution

4.3.3.1 Installation

(1) Install equipment in accordance with manufacturer's instructions.

(2) The Private Party shall align the pump and engine shafts to within the manufacturer's recommended tolerances prior to system start-up.

4.3.3.2 Testing and Commissioning

(1) All hydrostatic tests, flushing and field acceptance test procedures outlined in Chapter 11 Acceptance Testing, Performance, and Maintenance of NFPA 20, shall be carried out.

4.4 FIRE WATER PIPING WORK

4.4.1 General

4.4.1.1 General Requirement

(1) The Private Party shall furnish and install fire water pipes as shown on specified herein.

4.4.1.2 Standard and Reference

Pipes and Fittings shall comply with the following codes and standards.

(1) National Fire Protection Association (NFPA)

NFPA 13/2002	:	Standard for the Installation of Sprinkler Systems
NFPA 14/2002	:	Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems
NFPA 16/1999	:	Standard for the Installation of Foam-Water sprinkler and Foam-Water Spray system
NFPA 20/2002	:	Standard for the Installation of Centrifugal Fire Pumps
NFPA 24/2002	:	Standard for the Installation of Private Fire Service Mains and Their Appurtenances
NFPA 2001/2002	:	Standard on Clean Agent Fire Extinguishing Systems

(2) Underwriters Laboratories, Inc. (UL)

UL 213	:	Rubber Gasketed Fittings for Fire-Protection Service

(3) American Society of Mechanical Engineers (ASTM)

ASTM A53	:	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A183	:	Specifications for Ductile Iron Castings
ASTM A234	:	Standard Specification for Piping Fittings of Wrought-Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A536	:	Specifications for Ductile Iron Castings

(4) British Standard (BS)

BS 143 & BS 1256	:	Threaded pipe fittings in malleable cast iron and cast copper alloy
BS 1387	:	Specification for screwed and socketed steel tubes and tubulars and for plain end steel tubes suitable for welding or for screwing to BS 21 pipe t hreads

(5) American Water Works Association (AWWA)

AWWA C203	:	Coal-Tar Protective Coatings and Linings for Steel Water Pipelines Enamel and Tape - Hot Applied

(6) American Welding Society (AWS)

AWS D10.9	:	Specification for Qualification of Welding Procedures and Welders for Piping and Tubing

4.4.1.3 Submittals

(1) The Private Party shall submit all material, catalog, material lists and technical data request for approval before installation.

4.4.1.4 Warranty

(1) All part or the piping work shall be guaranteed by the Private Party at least 2 year after handover.

4.4.1.5 Delivery, handling, storage and creaming.

(1) Pipes shall be delivered and stored with plugged ends. Ends shall be kept closed with temporary covers during erection.

(2) Before any pipe is installed, it shall be opened and pounded to remove any foreign substances, or swabbed, if necessary, for thorough cleaning.

(3) Pipes shall be stored on racks in a suitable warehouse or under cover to avoid rusting. If necessary, carbon steel pipes shall be coated with anodized rust converter or red lead primer.

(4) During the course of installation, the Private Party shall take every precaution to prevent any debris from being left in the pipes. He shall be responsible for any damage that may occur.

(5) Immediately after erection, exposed threads at all fittings shall be painted with zinc-chromate paint, and after welding each joint shall be wire-brushed and then painted with zinc-chromate paint.

(6) Before start-up all piping systems shall be thoroughly flushed with water until it runs clear.

4.4.2 Materials

4.4.2.1 Description

(1) Wet Pipe

Wet pipe shall be used for standpipe, riser, automatic sprinkler system, fire hose, fire hydrant, and fire department connection.

(2) Dry Pipe

Dry pipe shall be used for Escalator Sprinkler Protection System (ESPS), Deluge/Pre-action set for some special area.

(3) Drain Pipe

Drain pipe shall be used for drain water from the system.

(4) Gas Suppression Pipe

Gas suppression pipe shall be used for electrical rooms.

(5) Foam Concentrated Pipe and Foam Water Pipe

Foam concentrated Pipe and Foam Water Pipe shall be used for Water-Foam sprinkler and spray System for specific area.

4.4.2.2 Component

(1) Wet Pipe

(a) Fire water pipe for wet pipe system shall be black steel pipe, ERW Schedule 40 conforming to ASTM A53.

(b) Welding methods shall be used for joining pipes of sizes up to Ø 50 mm.

(c) Grooved couplings shall be used for joining pipes of Ø 65 mm. diameter and above.

(2) Dry Pipe

(a) Fire water pipe for Dry pipe system shall be galvanized steel pipe conforming to BS 1387 class H.

(b) Threading methods shall be used for joining pipes of sizes up to Ø 50 mm.

(c) Grooved couplings shall be used for joining pipes of Ø 65 mm. diameter and above.

(3) Drain Pipe

(a) Drain pipes shall be galvanized steel pipe conforming to BS 1387 class M.

(b) Threading methods shall be used for joining pipes.

(4) Gas Suppression Pipe

(a) Gas suppression pipe shall be black steel pipe, SEAMLESS Schedule 40 conforming to ASTM A53.

(b) Welding methods shall be used for joining gas suppression pipes.

(5) Foam Concentrated Pipe and Foam Water Pipe

(a) Foam Concentrated Pipe shall be 316 stainless steel.

(b) Foam Water Distribution Pipe shall be Schedule 40 steel pipe, ASTM A53, grade A or B, Seam.

(6) Fittings

(a) Fittings for welded, black steel pipes shall be of wrought carbon and alloy steel for modulate and elevated temperature, conforming to ASTM A234.

(b) Fittings for grooved, black steel pipes shall be of ductile-iron conforming to ASTM A-536, UL 213 listed and FM approved.

(c) Fittings for galvanized steel pipes shall be galvanized malleable iron, conforming to BS 143 and BS 1256.

(d) Fittings for Foam Concentrated Pipe and Foam Water Pipe shall be Grooved or weld or Thread or Weld.

(7) Grooved Couplings

Rigid and flexible grooved couplings shall be UL 213 listed and FM approved, complete set from the factory.

The following items shall be included:

(a) Housing

Housing shall be made of ductile-iron conforming to ASTM A536 Grade 65-45-12, 448 MPa. (65,000 psi.) minimum tensile strength, 310 MPa. (45,000 psi.) minimum yield strength and 12% minimum elongation.

(b) Gasket

Gasket shall be made of EPDM (ethylene propylene diene monomer) Grade E for water services.

(c) Bolts and Nuts

Track head bolts and nuts shall conform to ASTM A183, 758 MPa. (110,000 psi) minimum tensile strength.

(8) Hanger and Supports

All hangers and steel supports shall be hot dip galvanized for normal area, and stainless steel for humid and corrosive area.

4.4.3 Execution

4.4.3.1 Installation

(1) General

All piping shall be installed parallel to, or at right angles with, the building walls and partitions. A pitch in the direction of flow and drain shall be not less than 1 : 500. Branches from water mains shall be taken in a manner that facilities venting and draining. Reductions in bore shall be formed eccentrically to facilitate venting, except on vertical pipes where concentric reduction may be used.

All water piping shall be installed in such a way that all circuits can be completely drained off and all air pockets in the water circuits shall be suitably vented.

Clearance between pipe works and equipment or machinery shall be adequately provided to facilitate maintenance. Overhead clearance shall be at least 600 mm. over access ways, and where possible the projection of valve stems into access ways shall be avoided. Pipe works and pumps shall be so arranged that the removal for maintenance of the equipment can be carried out with minimum dismantling. Provision of all pipe fittings and accessories necessary for the efficient functioning of the various systems shall be included.

Pipes shall be installed in continuous lengths as long as possible. Except where required to be connected to fitting outlets or headers, they shall be joined by welding, solvent welding, screwing or soldering as approved or indicated in the Specification.

(2) Appearance

All pipes shall be installed in an appropriate manner to present a neat and orderly appearance, using fittings for all changes of direction, and arranging pipe runs parallel to or at right angles with structural members of the building, to provide utmost head-room and to clear lights and other obstructions. In general, suspended pipes shall be installed as closely as possible to the overhead structure.

(3) Workmanship

All pipes shall be cut accurately to measurements established at the site, and shall be worked into place without springing or forcing. Piping shall be installed so that it may expand and contract freely without injury to itself or other work. Steel and wrought-iron pipe shall be cut with pipe cutters and threaded with sharp, clean dies. All cut sections shall be reamed to remove all burrs and to restore the pipe to full diameter. All changes in size shall be made with reducing fitting. Pipe bends and bushings are prohibited.

(4) Location of Device

All valves, cleanouts, equipment, accessories, and devices shall be so located that they are accessible for repair and replacement.

(5) Storage and Cleaning

Pipes shall be delivered and stored with plugged ends. Ends shall be kept closed with temporary covers during erection. Before any pipe is installed, it shall be opened and pounded to remove any foreign substances, or swabbed, if necessary, for thorough cleaning.

Pipes shall be stored on racks in a suitable warehouse or cover to avoid rusting. If necessary, carbon steel pipes shall be coated with anodic rust converter or red lead primer.

During the course of installation, the Private Party shall take every precaution to prevent any debris from being left in the pipes. He shall be responsible for any damage that may occur.

Immediately after erection, exposed threads at all fittings shall be painted with zinc-chromate paint, and after welding each joint shall be wire-brushed and then painted with zinc-chromate paint.

Before start-up, all piping systems shall be thoroughly flushed with water until it runs clear.

Fixtures and equipment shall be lightly covered and protected against damage. At the completion of the work, fixtures, materials and equipment shall be thoroughly cleaned and delivered in a satisfactory condition.

(6) Connection to Equipments

Connections to coils, pumps and other equipment shall be made in such a manner that undue strains between pipes and equipment are eliminated. Unions and/or flanges shall be used to facilitate the removal of the equipment.

(7) Expansion and Contraction

The piping systems shall be installed so that there will be no damage due to expansion and contraction during operation.

Packless type expansion connectors shall be used where the expansion and contraction of the pipe is excessive or cannot be compensated by expansion loops or offsets.

(8) Differential Settlement

The piping systems shall be installed so that there will be no damage due to differential settlement of the pipe supports after installation. The problems could be avoided by providing flexible connections.

(9) Sleeves

Vertical pipes passing through floors shall be provided with sleeves of black steel pipes. Sleeves shall be of a proper length to pass through the entire floor construction and shall terminate 50 mm. above the finished floor level.

Horizontal pipes passing through walls and partitions shall be provided with full thickness sleeves made of standard weight black steel pipes.

Sleeves shall be large enough to leave not less than 12.5 mm. clearance around the pipe and covering insulation, if there is any. Sleeves shall be set in place where the walls and partitions are built.

Sleeves in concrete work shall be flanged at the bottom or provided with temporary centering caps and securely nailed or screwed to formwork before the concrete is poured.

Provide chromium-plated escutcheon, where exposed pipes pass through walls or floors.

When sleeves are installed through a fire wall, the clearance between sleeves and pipes shall be filled with fire-resistant material. The fire rating of the fire-resistant material shall be at least equivalent to that of the fire wall.

When pipes pass through waterproof walls, water retaining rings with approved type of sealant shall be applied.

(10) Joints for Threaded Pipes

Joints for threaded pipes shall be made with an approved Teflon tape or graphite compound applied to the male threads only. Excess jointing material shall be removed after the joint is made. Threads shall be clean-cut, tapered threads with the ends being reamed before installation.

(11) Flanged Pipe Joint

Flanged joints shall be installed at valves of size Φ 65 mm. diameter and above, and at other places where necessary. Jointing flanges shall be truly parallel to each other so that bolts are used only to tighten joints, rather than correct alignment. Flanges shall be chosen to suit the maximum working pressure of the system. Bolts, nuts and washers shall be cadmium-plated steel.

(12) Welded Pipe Joint

(a) Welding methods that comply with all of the requirements of AWS D10.9, Specification for Qualification of Welding Procedures and Welders for Piping and Tubing, Level AR-3, are acceptable means of joining fire protection piping.

(b) Sprinkler piping shall be shop welded.

(c) No welding shall be performed if there is impingement of rain or high wind on the weld area of the pipe product.

(d) When welding is performed :

(i) Holes in piping for outlets shall be cut to the full inside diameter of fittings prior to welding in place of the fittings.

(ii) Disc shall be retrieved.

(iii) Openings cut into piping shall be smooth bore, and all internal slag and welding residue shall be removed.

(iv) Fittings shall not penetrate the internal diameter of the piping.

(v) Steel plates shall not be welded to the ends of piping or fittings.

(vi) Fittings shall not be modified.

(vii) Nuts, clips, eye rods, angle brackets, or other fasteners shall not be welded to pipe or fittings.

(e) Torch cutting and welding shall not be permitted as a means of modifying or repairing sprinkler systems.

(f) A welding procedure shall be prepared and qualified by the Private Party or fabricator before any welding is done. Qualification of the welding procedure to be used and the performance of all welders and welding operators is required and shall meet or exceed the requirements of American Welding Society Standard AWS D10.9, Level AR-3.

(g) Private Party or fabricators shall be responsible for all welding they produced. Each fabricator shall have available to the authority having jurisdiction an established written quality assurance procedure ensuring compliance with the requirements shown in this item.

(13) Grooved Coupling

(a) Rigid couplings shall be used for horizontal pipeline, mechanical room and other applications where rigidity is required. The built-in teeth and T&G (tongue and groove) mechanisms provide a rigid, locked-in connection.

(b) Flexible couplings shall be used for riser pipeline and other applications where expansion, contraction or deflection caused by temperature change, seismic tremors or other sources of vibration are factors.

(c) Grooved couplings are permitted for using the roll-groove method by roll grooving machine. Mechanically cut grooves are not permitted

(d) Lubricant shall be used to the sealing lips and exterior of the gasket as well as the interior of the coupling housings.

(14) Hanger and Supports

All pipes shall be securely supported in accordance with NFPA13 "Installation of Sprinkler System", 2-6 Hangers. Horizontal piping shall be supported by adjustable clevis type hangers with solid rods securely attached to the building structure. Where several pipes run in a parallel fashion, trapeze hangers may be used in lieu of separate hangers. All hangers shall have turnbuckles or other approved means of adjustment. Where pipes, such as those from individual toilet rooms to main stacks, are not low enough to permit the use of turnbuckles, other means of adjustment shall be used. Chains, straps, perforated bars, or wire hangers will not be accepted. All hangers and supports shall be hot-dip galvanized..

For all pipes where the hanger clips bear directly on pipes and for hangers of dissimilar metals, suitable aeparation with a layer of felt shall be provided to prevent corrosion. Hangers on structural steel is absolutely prohibited, unless with the express approval from the Engineer's Representative.

Anchors for steel pipes shall be welded directly to the pipe wall and securely bolted to the building structure. Hangers in the plant room shall be supported on springs.

Supporting brackets shall be fastened to concrete by means of inserts or expansion bolts, to brickwork by means of expansion bolts, and to hollow masonry by means of toggle bolts.

Two fixings per bracket shall be provided as follows :

Nominal Pipe Size (mm.)	Fixing Size (mm.)
Up to 65	6.4
80 to 150	9.5
200 to 300	12.7

(15) Floor, Wall and Ceiling Plate

Furnish and install plates on all entry and exit openings for all exposed pipes passing through finished walls, finished partitions, finished ceilings, and floors above grade. Plates shall be large enough to completely close the hole around the pipe. Wall and ceiling plates shall have set screws; spring clips will not be acceptable. Where necessary to cover beads of fittings, special deep escutcheons shall be provided.

(16) Cutting and Repairing

The work shall be careful laid out in advance. Cutting of structural works shall be done only with specific approval from the Engineer's Representative. Damage from the cutting shall be carefully repaired by skilled workmen of the trade involved.

(17) Invert Elevation

The Private Party shall verify the proposed invert elevations prior to laying pipes.

(18) Underground Pipes

All steel pipes to be buried underground shall be externally coated in the mill of the fabricator. Material shall conform to AWWA C203.

Sequence of application

(a) Sandblast

(b) Apply coat of plasticized coal tar primer.

(c) Apply flood coat of hot plasticized coal tar enamel, 2.4 mm. minimum thickness.

(d) Apply spiral wrap with 20 mil fiberglass.

(e) Apply flood coat of hot plasticized coat for enamel, 2.4 mm. minimum thickness.

(f) Apply spiral wrap with 6.8 kg asbestos felt.

(g) After the top coat has been cured at approximately 20 C for not less than 16 hours, the external protective coating shall be tested electrically using an approved holiday detector and shall be free of missed spots.ion shall be as follows :

Underground pipe supports attached to the building structure shall be made of stainless steel.

Back fill and under-fill shall be made with sand.

4.4.3.2 Testing and Commissioning

(1) Flushing of Piping.

(a) Piping between the fire department connection and the check valve in the inlet pipe shall be flushed with a sufficient volume of water in order to remove any construction debris and trash accumulated in the piping prior to the completion of the system and prior to the installation of the fire department connection.

(b) Underground Piping

(i) Underground piping, from the water supply to the system riser, and lead-in connections to the system riser shall be completely flushed before the connection is made to downstream fire protection system piping.

(ii) The flushing operation shall be continued for a sufficient time to ensure thorough cleaning.

(iii) The minimum rate of flow shall be not less than one of the following:

- Hydraulically calculated water demand flow rate of the system, including any hose requirements.

- Flow necessary to provide a velocity of 3.1 m/sec (10 ft/sec) in accordance with table.

Pipe Size		Flow Rate	
In.	mm.	gpm	L/min.
4	100	390	1,476
6	150	880	3,331
8	200	1,560	5,905
10	250	2,440	9,235
12	300	3,520	13,323

- Maximum flow rate available to the system under fire conditions.

(2) Hydrostatic Tests

(a) All piping and attached appurtenances subjected to system working pressure shall be hydrostatically tested at 13.8 kg/cm2 (200 psi) and shall maintain that pressure without loss for 2 hours.

(b) The test pressure shall be read from a gauge located at the low elevation point of the system or portion being tested.

(c) Piping between the exterior fire department connection and the check valve in the fire department inlet pipe shall be hydrostatically tested in the same manner as the balance of the system

4.5 VALVE AND ACCESSORIES

4.5.1 General

4.5.1.1 General Requirement

(1) Valves and accessories shall be provided as indicated on specified herein.

(2) Shut-off valves shall be furnished as necessary for a satisfactory operation of all apparatus.

(3) Valves of the same type shall be supplied by the same manufacturer.

4.5.1.2 Standard and Reference

Valve and accessories shall comply with the following codes and standards.

(1) National Fire Protection Association (NFPA)

NFPA 10/2002	:	Standard for Portable Fire Extinguishers
NFPA 13/2002	:	Standard for the Installation of Sprinkler Systems
NFPA 14/2002	:	Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems
NFPA 16/1999	:	Standard for the Installation of Foam-Water sprinkler and Foam-Water Spray system
NFPA 20/2002	:	Standard for the Installation of Centrifugal Fire Pumps
NFPA 24/2002	:	Standard for the Installation of Private Fire Service Mains and Their Appurtenances
NFPA 70/2002	:	National Electrical Code
NFPA 72/2002	:	National Fire Alarm Code

(2) Underwriters Laboratories, Inc. (UL)

UL 8	:	Foam Fire Extinguishers
UL 154	:	Carbon-Dioxide Fire Extinguishers
UL 193	:	Alarm Valves for Fire-Protection Service
UL 199	:	Automatic Sprinklers for Fire-Protection Service
UL 213	:	Rubber Gasketed Fittings for Fire-Protection Service
UL 246	:	Hydrants for Fire-Protection Service
UL 260	:	Dry Pipe and Deluge Valves for Fire-Protection Service
UL 262	:	Gate Valves for Fire-Protection Service
UL 312	:	Check Valves for Fire-Protection Service
UL 346	:	Waterflow Indicators for Fire Protective Signaling Systems
UL 405	:	Fire Department Connections
UL 464	:	Audible Signal Appliances

UL 521	:	Heat Detectors for Fire Protective Signaling Systems
UL 626	:	Water Fire Extinguishers
UL 668	:	Hose Valves for Fire-Protection Service
UL 711	:	Rating and Fire Testing of Fire Extinguishers
UL 753	:	Alarm Accessories for Automatic Water-Supply Control Valves for Fire Protection Service
UL 789	:	Indicator Posts for Fire-Protection Service
UL 864	:	Control Units and Accessories for Fire Alarm Systems
UL 1091	:	Butterfly Valves for Fire-Protection Service
UL 1468	:	Direct Acting Pressure Reducing and Pressure Restricting Valves
UL 2129	:	Halocarbon Clean Agent Fire Extinguishers

(3) Factory Mutual (FM)

(4) British Standard / European Standard (BS EN)

BS EN 671-1	:	Fixed fire fighting systems. Hose systems. Hose reels with semi-rigid hose
BS EN 694	:	Fire-fighting hoses. Semi-rigid hoses for fixed systems

(5) Listed of Approved Fire and Security Products and Services, (LPCB)

Part 5, Section 7	:	Multiple jet controls

(6) Thai Industrial Standard (TIS)

TIS 332	:	Dry Chemical Portable Fire Extinguishers

4.5.1.3 Submittals

(1) The Private Party shall submit all material, catalog, material lists and technical data request for approval before installation.

4.5.1.4 Warranty

(1) All portable fire extinguishers shall be guaranteed by the Private Party at least 5 years after handover.

(2) All part or the valve and accessories shall be guaranteed by the Private Party at least 2 years after handover.

4.5.2 Materials

4.5.2.1 Description

(1) The valves and accessories shall be the types or models which are suitable for the working fluid in the system.

(2) The rated working pressure of the valve as specified for the working fluid shall be at least 1.5 times of the actual working pressure which could be specified as 12 kg/cm2 for general area and shall be 17.5 kg/cm2 or in fire pump room.

(3) The diameter of hand-wheels for valves shall be of a suitable size so as to allow tight closure by hand with the application of reasonable force so that neither additional leverage nor damage shall be imposed upon their stem, seat and disc. Where indicated or required, for inaccessible overhead valves, chain-operated hand-wheels including rust-roof chain and chain guide shall be provided.

(4) Escalator Sprinkler Protection System (ESPS) shall be provided for the total protection of the whole escalator covering all potential fire risk areas. In the event of fire, ESPS control panel shall be receiving signals from cross zone linear heat detectors, and send a signal to burst Multi-Jet control glass bulb through the electric actuator. Water shall flow through Multi-Jet control valve and sprinkler to suppress fire. The control panel will also check system status such as fault, alarms, flow, and supervisory switch.

(5) Deluge/Preaction control panel shall be receiving signals from cross zone photoelectric smoke detectors, and relay the signal to a solenoid valve. Water shall flow through Deluge/Preaction valve and sprinkler to suppress the fire. The control panel will also check system status such as fault, alarms, supervisory switch, and pressure switch.

(6) The Foam Spray Set and Foam Fire Hose Set shall be provided for specific fire suppression requirement of DP08-HS, Hazardous Storage on Depot Platform, which store the flammable and explosive materials.

Supply and installation of the Foam Spray Set and Foam Fire Hose set shall be carried out in accordance with latest NFPA 16.

In the event of fire, The Deluge Valve (NC) shall be activated by both Automatic Pilot Sprinkler and Manual Mechanism. The water from wet standpipe system and Concentrated Foam in storage tank shall be provided, mixed at Line Proportioner and sprayed at Nozzle for fire suppression.

The Deluge Foam Spray discharge density shall be in accordance with the applicable occupancy standard for foam water system but in no case less than 6.5 l/mim/sq.m. and foam solution discharge period shall be of 15 min.

For Foam fire hose, the minimum flow rate shall be 190 l/min at 5 bar and the minimum foam solution discharge period shall be of 15 min.

Nozzle spacing shall be in accordance with the listed or approved coverage for each nozzle type. In all cases, the need for additional nozzles shall be considered based upon site conditions and manufacturers recommendations.

4.5.2.2 Component

(1) Gate Valves (OS&Y)

(a) Valves of sizes up to Ø 50 mm. shall be bronze with threaded ends, solid wedges and rising stems.

(b) Valves of sizes Ø 65 mm. and larger shall be cast-iron with flanged ends, solid wedges and rising stems.

(c) Valves shall be UL 262 listed and FM approved.

(2) Butterfly Valves

(a) A butterfly valve may be used instead of a gate valve if its size is over or equal to Ø 80 mm. in diameter.

(b) Butterfly valves shall be cast iron or ductile iron, grooved end.

(c) Supervisory switch shall be internal built in.

(d) Butterfly valves shall be UL 1091 listed and FM approved.

(3) Swing-Check Valves

(a) Valves shall be of the swing type suitable for the horizontal or vertical operation with two-piece hinge and accessible disc cover.

(b) Valves of sizes up to Ø 50 mm. shall be bronze with thread ends and full area Y pattern bodies.

(c) Valves of sizes Ø 65 mm. and larger shall be cast-iron, swing pattern and bronze-trimmed with flanged ends or wafer type.

(d) Valves shall be UL 312 listed and FM approved.

(4) Silent-Check Valves

(a) Silent-type check valves or Lift-check valves shall be installed at the location where noise and water hammer would cause a problem.

(b) The valve shall be of a spring closed type. Seats, discs, and springs shall be bronze or stainless steel.

(c) Valves of sizes up to Ø 50 mm. shall be bronze with threaded ends.

(d) Valves of sizes Ø 65 mm. and larger shall be cast-iron with flanged ends or wafer type.

(e) Valves shall be UL 312 listed or FM approved.

(5) Ball Valves

(a) Ball valves shall be made cast bronze or brass with threaded ends.

(b) Ball valves shall be 35 kg/cm2 (500 psi.) working pressure, UL 1091 listed or FM approved.

(6) Gate Valve with Indicator Post

(a) Gate valve with indicator post shall be installed in fire pump for servicing of fire water tank.

(b) The following items shall be included:

(i) Gate Valve

Gate valve shall be ductile iron or cast iron, non rising stem type, flanged ends, working pressure at least 12 kg/cm^2 (175 psi), UL 262 listed and FM approved.

(ii) Indicator Post

Indicator Post shall be selected compatible with the gate valve, adjustable vertical indicator posts type, made of cast iron or ductile iron, UL 789 listed and FM approved.

(7) Wet Pipe Alarm Valves Set

(a) Alarm valves shall be of the vertical or horizontal pattern and shall be provided with an isolating valve to allow removal for maintenance.

(b) The valves shall be designed for a wet pipe water sprinkler system and actuated by breaking sprinkler heads.

(c) Each alarm valve shall be fitted with a water motor and gong, and an alarm contact for connection to the central fire alarm panel.

(d) The following items shall be included:

(i) Water Motor Gang

Water motor gong shall be made of aluminum, stainless steel and other non-corrosive materials to prevent rust and staining. Water motor gong shall be UL 753 listed and FM approved.

(ii) Retard Chamber

Retard chamber shall be ductile-iron body, FM approved, and UL 753 listed rated for 20 kg/cm2 (300 psi.).

(iii) Pressure Switch

(iv) Water Supply Pressure Gauge

(v) System Pressure Gauge

(vi) Main System Drain Valve

(e) Alarm valves shall be UL 193 listed and FM approved.

(8) Escalator Sprinkler Protection System (ESPS)

Escalator sprinkler protection system shall be installed in escalator to protected escalator structure. The detection shall be cross zone detection.

ESPS shall be included with following:

(a) Multi-Jet Control Valves

(i) Multi-jet control valves shall be single inlet with double outlets, □50x40x40 mm. or □80x50x50.

(ii) Multi-jet control valves shall be included with following:

- Frangible glass bulb

  Frangible glass bulb shall be temperature rating at 93°C.

- Electric Actuator

(iii) Multi-jet control valves shall be listed of LPCB approved for Fire and Security Products and Services, Part 5, Section 7.

(b) ESPS Control Panel (Water Release Control Panel)

(c) Automatic Sprinkler

(d) Indicating Valve with Supervisory Switch

Indicating valve with supervisory switch shall be OS&Y gate valve or butterfly valve.

(e) Test Valve (OS&Y gate valve or ball valve)

(f) Drain Valve (OS&Y gate valve or ball valve)

(g) Flow Switch

(h) Linear Heat Detector Cable

(i) The linear heat detector cables (or line type heat detectors) shall be of cable comprised with two metal (or tinned copper-covered steel) conductors insulated with proper heat sensitive polymer.

(ii) The detector cables shall be resistant to mechanical damage, complete with low smoke zero halogen sheaths and shall be suitable for the environment in which the cables will be installed.

(iii) The approval standard of detector cables shall be UL 521 listed or FM approved.

(iv) All bends of the cables shall be installed as per the recommendation from manufacturer.

(v) Wiring method of the cable per one zone shall be class B with end of line resistor and which is comprised of the following accessories:

- Fire resistant cable wired from ESPS control panel to zone box, which have the suitable conductor size as per recommendation from the detector cable manufacturer.
- Zone box for starting point of the detector cable, which shall be comprised of a weather proof junction box (IP54), suitable cable glands and proper cable terminal for termination between both types of the cable.
- End zone box for installing of end of line resistor line, which shall be comprised of a weather proof junction box (IP54), suitable cable gland s and proper cable terminal for termination between the detector cable and end of line resistor.
- Other accessories as per recommendation of the detector cables manufacturer.

(vi) Electrical characteristic of the detector cables (voltage rating, cable resistance including end of line resistance) shall be matched with the input circuit of ESPS control panel for complete operation.

(vii) Temperature characteristic of the detector cables shall be as followed:

- Maximum ambient temperature Up to 65°C
- Activated alarm temperature 79°C - 90°C

(9) Deluge Sprinkler Set

Deluge sprinkler set shall be included with following:

(a) Deluge Valve

The body of the deluge valve is constructed of high tensile strength ductile iron ASTM A536 Grade 65-45-12 and bronze clapper having considerable ductility to avoid damage in ordinary handling. Valves shall be UL 260 listed and FM approved.

(b) Deluge Valve Control Panel (Water Release Control Panel)

(c) Automatic Sprinkler

(d) Indicating Valve with Supervisory Switch

Indicating valve with supervisory switch shall be OS&Y gate valve or butterfly valve.

(e) Mini Horn with Strobe Light

Mini horn with strobe light shall refer to Section 22.6 Fire Alarm System.

(f) Electric Alarm Bell

Electric alarm bell shall be Ø 150 mm. (6”) with 24 VDC. The housing shall be a high quality die casting with a baked red finish. UL 464 listed and FM approved.

(g) Pressure Switch

(h) Photo Electric Smoke Detector

Photo electric smoke detector shall refer to Section 22.6 Fire Alarm System.

(i) Solenoid Valve

Body shall be brass with 24 VDC, UL 260 Listed and FM approved.

(10) Water Release Control Panel

(a) Water release control panel shall be comprised of at least the following:

(i) Microprocessor base controlled

(ii) Alarm and trouble resound

(iii) General alarm and trouble relays

(iv) Disable / Enable controls per initiating zone

(v) Battery Fail and Earth Fault supervision

(vif) 24 hours standby battery with charger

(vii) Cross zone detection

(b) Input circuits shall be at least 4 circuits,

(c) Output circuits shall be at least 4 circuits,

(d) Front Panel Control Switches shall be at least 4 switches.

(i) Switch 1 - Tone Silence

(ii) Switch 2 - Alarm Silence

(iii) Switch 3 - Alarm Activate

(iv) Switch 4 - System Reset

(e) Water release control panel shall be UL 864 listed and FM approved.

(11) Hose Valves

(a) Angle Hose Valves

(i) Valves of size Ø 65 mm. in diameter shall be cast brass with female thread at both inlet and outlet sides.

(ii) Valves shall be installed when the inlet pressure is equal to or less than 7.0 kg/cm2 for Ø 40 mm. diameter hoses or 12 kg/cm2 for Ø 65 mm. hoses.

(iii) Valves shall be included with cast brass caps and chains, chrome finished.

(iv) Angle Hose Valves shall be UL 668 listed and FM Approved.

(b) Adjustable Pressure Restricting Angle Hose Valves

(i) Valves of size Ø 65 mm. in diameter shall be cast brass with female thread at both inlet and outlet sides.

(ii) Valves shall be used to control the outlet water pressure at 7.0 kg/cm2 for Ø 40 mm. diameter hoses and 12 kg/cm2 for Ø 65 mm. diameter hoses, where the inlet pressures exceed these figures.

(iii) Valves shall be included with cast brass caps and chains, chrome finished.

(iv) Angle hose valves shall be UL 668 listed or FM Approved.

(12) Pressure Reducing Valves

(a) Pressure reducing valves shall maintain a constant downstream pressure regardless of varying inlet pressure. They shall be hydraulically operated, pilot controlled diaphragm-type globe or angle valves. The main valve shall have a single removable seat and a resilient disc. The stem shall be guided at both ends by a bearing in the valve cover and an integral bearing in the valve seat. No external packing glands are permitted, and there shall be no pistons operating the main valve.

(b) The pilot control shall be a direct-acting, adjustable, spring loaded, normally open, diaphragm valve, designed to permit flow when controlled pressure is less than the spring setting. The control system shall include a fixed orifice.

(c) The body of main valve shall be cast-iron with screwed or flanged ends.

(d) Valves shall be UL 1468 listed and FM approved.

(13) Pressure Relief Valves

(a) Pressure relief valves shall actuate to relieve excess pressure in a fire protection system.

(b) They shall be pilot controlled and back pressure shall not affect the set point. They shall be actuated by line pressure through a pilot control system and open fast in order to maintain steady system pressure as system demand decreases. They shall close gradually to control surges and shall re-seat drip-tight within 5% of its pressure setting.

(c) The main valve shall be of the hydraulically-operated, pilot-controlled, diaphragm type, globe or angle valve.

(d) The pilot control shall be a direct-acting, adjustable, spring-loaded, diaphragm type valve designed for modulating service to permit flow when controlling pressure exceeds spring setting.

(e) The body of main valve shall be cast-iron with screwed or flanged ends.

(14) Pressure Regulating Valves

Pressure regulating valve shall be for Ø 65 mm cast brass, chrome finished, UL 1468 listed or FM approved.

(15) Sprinkler Heads

Sprinkler heads shall be UL 199 listed and FM approved.

(a) Upright Sprinkler Heads

The exposed sprinkler heads shall have the following features:

(i) Applicable for areas without false ceilings.

(ii) Frangible bulb type.

(iii) Upright style.

(iv) Ø 15 mm. (1/2 inch) in diameter nominal orifice.

(v) Chrome finish.

(vi) Temperature rating shall be ordinary hazard of 68°C.

(vii) Sprinkler guards shall be provided in the area which sprinkler head possible accidently broken.

(b) Pendant Sprinkler Heads

Pendant sprinkler heads shall be of the recessed type suitable for incorporation into a high quality metal tray type false ceiling.

They shall be the following features:

(i) Minimum projection below ceiling.

(ii) Frangible bulb type.

(iii) Pendant style.

(iv) Ø 15 mm. (1/2 inch) in diameter nominal orifice.

(v) Chrome-plated with 2 pieces of Escutcheon Plates finish to suit decorative scheme.

(vi) Temperature rating shall be ordinary hazard of 68°C.

(vii) Sprinkler guards shall be provided in the area which sprinkler head possible accidently broken.

(c) Sidewall Sprinkler Heads

The sidewall sprinkler shall be the following features:

(i) Applicable for those areas where ceiling sprinklers cannot be used.

(ii) Frangible bulb type (open type within escalator trusses).

(iii) Ø 15 mm. (1/2 inch) in diameter nominal orifice.

(iv) Chrome-plated with 1 piece of Escutcheon Plates finish to suit decorative scheme.

(v) Temperature rating shall be ordinary hazard of 68°C.

(vi) Water distribution at pressure 2.0 kg/cm2 not less than 6 m. length and 4.5 m. width.

(16) Flow Switches

(a) Flow switches shall be fitted on all sprinkler systems, hydrants and hose points, along with other pipe branches.

(b) Each unit shall have tamper-proof switch housing with flexible flow paddle, micro-switches and retard feature to minimize false alarm. Retard setting shall be adjustable.

(c) Each unit shall have a volt-free contact, the wiring from which will be carried out under the fire detection and alarm system work.

(d) Flow switch shall be UL 346 listed and FM approved.

(17) Supervisory Switches

(a) Supervisory switches or monitor switches shall be fitted on main and branch isolating valves in the fire pump room and tank room. The monitor switches are for the supervision of the open position of valves which control water supplies to automatic sprinkler or stand pipe fire protection system. Supervision of the open position of a main control valve is to indicate a condition, i.e., closing of the valve that could prevent the required operation of a fire protection system.

(b) Supervision switches or monitor switches are operated by movement of the trip rod or by removal of the cover. The trip rod is spring loaded and double action, consequently, lateral movement of the trip rod, in either direction from its normally installed position, will result in operation of the switching components.

(c) The monitor switch has one single pole double throw snap-action switch.

(d) The switching components are enclosed in NEMA type 1 general purpose indoor rated housing. The electrical switch contacts are rated at 220 VAC, 15 A.

(e) In addition, all valves indicated as supervised shall be locked open with strap and padlock.

(f) All Ø 65 mm. hydrants shall be locked closed using the same method.

(g) Supervisory Switches shall be UL 753 listed and FM approved.

(18) Pressure Switch

Pressure Switch shall be designed for use in wet, dry, deluge, and pre-action automatic sprinkler systems to indicate a discharge from a sprinkler by increasing and/or decreasing of pressure.

Pressure switch shall have the following features:

(a) UL Pressure Rating : 250 PSI

(b) Pressure Connection : 15 mm. (1/2") NPT Male

(c) Enclosure : Die-cast with textured red powder coat finish

(d) Pressure switch shall be UL 753 listed and FM approved.

(19) Pressure Gauges Set

(a) Pressure gauges shall be of the bourdon type, stainless steel casing, round type of Ø 100 mm. dial and scale range of approximately 150 percent of the normal operation. Pressure readings shall be in kg/cm2 and psig (dual scale).

(b) Needle valve and pressure snubber, with working pressure corresponding with the piping system shall be provided for each pressure gauge.

(c) Oil filled pressure gauges shall be selected where used adjacent to moving machinery, e.g. pumps.

(20) Automatic Air Vent

(a) Automatic air vent shall be installed at the top of riser.

(b) Automatic air vent shall be cast iron, thread end connection, Ø 25 mm. inlet, Ø 15 mm. outlet, working pressure at least 12 kg/cm2 (175 psi).

(c) Automatic air vent shall be FM approved.

(21) Flexible Connections

(a) Flexible connections at outlets of pumps shall be of stainless steel corrugated inner tube and stainless steel wire braid outside the tube with flanged ends.

(b) The flexible connectors shall be designed for excellent vibration and noise protection. Isolated tension members shall be provided to prevent excessive elongation.

(c) Flexible connections shall be suitable for the specified working fluid or specified working pressure and temperature.

(22) Expansion Joints

(a) Packless type expansion connectors shall be used where the expansion and contraction of the pipe is excessive or cannot be compensated by expansion loops or offsets.

(b) Anchors and pipe guides shall be provided and installed at the recommended locations.

(c) All expansion connectors shall have flanged ends with working pressure corresponding with the piping system.

(23) Strainers

(a) Water strainers shall be of the Y type.

(b) Strainers of Ø 50 mm. and smaller shall have bronze or iron bodies with screwed connections while Ø 65 mm. strainers and larger shall have iron bodies and flanged connections.

(24) Sight-glass

(a) Sight-glass shall be suitable for the specified working fluid or specified working pressure.

(b) Sight-glass shall have the following features:

Body	:	cast iron
View Window	:	clear acrylic

Covers : mild steel

O-rings : Buna-N

(25) Fire Department Connections

(a) The fire department connection shall have cast brass body with □65 mm. diameter two-way male instantaneous outlet connections, and incorporating individual clapper type non-return valves.

(b) Valves shall be included with cast brass caps and chains, chrome finished, and

(c) The unit shall be mounted in a recessed stainless steel box.

(d) Fire Department Connections shall be UL 405 listed and FM approved.

(26) Fire Hydrant

(a) Fire hydrant shall have cast brass body with Ø 65 mm. female thread outlet.

(b) Valves shall be included with cast brass caps and chains, chrome finished.

(c) Fire hydrant shall be UL 246 listed and FM approved.

(27) Fire Hose Reel Cabinets and Fire Hose Box Cabinets

(a) The cabinets shall be fabricated from stainless steel sheet with a minimum thickness of 1.6 mm.

(b) The cabinets shall be suitable for accommodating the fire fighting equipment and shall be complete with internal hinges, door locks and letter signs. The door shall be able to open 180°.

(28) Jet/Fog Spray Nozzle

(a) Jet/Fog spray nozzle shall be installed in fire hose box.

(b) Jet/Fog spray nozzle shall be Ø 65 mm, Ø 40 mm. with inlet quick coupling type.

(29) Fire Hose

(a) Fire hose shall be installed in fire hose box.

(b) Fire hose shall be Ø 65 mm, Ø 40 mm. with 30 m. long, completed with male and female quick coupling on each end.

(30) Quick Coupling Reducer

(a) Quick coupling reducer shall be installed in fire hose box.

(b) Quick coupling reducer to reduce hose size with size Ø 65 mm. male inlet and Ø 40 mm. female outlet.

(31) Fire Hose Reel

(a) Fire hose reel shall be installed in fire hose reel cabinet.

(b) Fire hose reel shall be Automatic, Recessed Swing Hose Reel type.

(c) The following items shall be included:

(i) Fire Reel Hose

Fire reel hose shall be red color, Ø 25 mm. x 30 meters conform to BS EN 694 Type A. Maximum working pressure at 15 kg/cm2 and theoretical burst pressure at 50 kg/cm2.

(ii) Hose Nozzle

Hose nozzle shall be manufactured in red nylon, include both twist grip and lever control to allow adjustment through jet/spray, shut-off positions. Hose nozzle shall comply with BS EN 671-1.

(iii) Automatic Stop Valve

The automatic stop valve opens to provide full capacity within just two revolutions of the reel.

(iv) Fire hose reel shall conform to BS EN 671-1 completely assembled from the factory.

(32) Portable Fire Extinguisher

(a) Multi-Purpose Dry Chemical Fire Extinguishers

(i) Each unit shall have capacity of 4.5 kg. and at least TIS 332 rating 6A:20B:C.

(ii) Multipurpose Dry Chemical Fire Extinguishers shall comply with TIS 332.

(b) CO2 Portable Fire Extinguishers

(i) Each unit shall have CO2 capacity of 4.5 kg. with at least UL 711 rating 10B:C.

(ii) CO2 portable fire extinguisher shall be UL 154 listed.

(c) Halotron Fire Extinguishers

(i) Each unit shall have Halotron capacity of 7.0 kg. with at least UL 711 rating 2A:10B:C

(ii) Halotron Fire Extinguishers shall be UL 2129 listed.

(d) Water Fire Extinguishers

(i) Each unit shall have capacity of 9.4 Liter (2.5 gallon) and UL 711 rating at 2A.

(ii) Water Extinguishers shall be UL 626 listed.

(e) Aqueous-Film Forming Foam Fire Extinguishers (AFFF)

(i) Each unit shall have capacity of 9.4 liters (2.5 gallons) and UL 711 rating at least 1A:20B.

(ii) Film-Forming Foam Fire Extinguishers shall be UL 8 listed.

(33) The Foam Spray Set and Foam Fire Hose Set

(a) Deluge Valve and Hydraulic operate trim.

(i) Deluge valve shall be Hydraulic Operated type, made from ductile iron, grooved ends connection, working pressure 300 psi., UL/FM approved

(ii) Deluge trim shall be comprise of Standard Hydraulic Trim, Alarm pressure Switch, Water motor gong.

(iii) The Deluge Valve List shall be refereed to Victaulic, Reliable, Viking, Star or equivalence

(b) Ball valve (Inlet and Outlet of Deluge valve)

(i) Ball valve made from Brass, grooved ends connection, working pressure 350 psi., UL/FM approved

(ii) The Ball Valve List shall be refereed to Victaulic, Reliable, Viking, Star or equivalence

(c) Foam Spray Nozzle

(i) Foam Spray nozzles made from Bronze frame, Brass Deflector and stainless steel screen Mesh, working pressure 175 psi., K-factor = 40 (lpm/bar^0.5), UL approved.

(ii) The Foam Spray Nozzle List shall be refereed to Victaulic, Reliable, Viking, Star or equivalence

(d) Line Proportioners

(i) Line Proportioners made from corrosion resistance brass, thread ends.

(ii) Minimum inlet pressure shall be 5.4 bar.

(iii) The Line Proportioners List shall be refereed to Akron, Chemguard, Elkhart, Minimax, Viking or equivalence

(e) Foam Storage tank

(i) Foam Storage tank shall be local made from 316 stainless steel capacity 500 litres, complete with manhole, sight glass, Air Vacuum vent

(f) Foam Concentrate

(i) Foam Concentrate shall be Synthetic Foam Alcohol Resistance type, 3% concentrate, (3%-3% AR-AFFF).

(ii) Specific Gravity 1.010 g/ml, pH 7.6, Viscosity < 3500 cps.

(iii) UL approved.

(iv) The Foam Concentrate List shall be refereed to Ansul, Chemguard, Elkhart, Minimax, Viking or equivalence

(g) Valves in Suction Line of Foam Concentrate

(i) Valves shall be Ball valve and Check Valve type. Made from 316 stainless body.

(ii) The Valves List shall be refereed to Ansul, Chemguard, Elkhart, Minimax, Viking or equivalence

(h) Pilot sprinkler Detector

(i) Pilot Sprinkler shall be quick response type, size ½” thread, K-factor = 80 (lpm/bar^0.5), 175 ‘F temperature, bulb type and Upright or Pendent style, made from brass and chrome finished , UL/FM approved.

(ii) The pilot detector shall be protected from accidental damage by Sprinkler guards.

(iii) The Pilot sprinkler Detector List shall be refereed to Ansul, Chemguard, Elkhart, Minimax, Viking or equivalence

(i) Strainer

(i) Strainer shall be Y type, made from cast iron body and Stainless steel screen, working pressure.175 psi.

(ii) The Strainer List shall be refereed to Ansul, Chemguard, Elkhart, Minimax, Viking or equivalence

(j) Pipe Material

Distribution piping shall be Schedule 40 steel pipe, ASTM. A53, GRADE A or B, SEAM.

(k) Fittings

Fittings shall be Grooved or Thread or Weld.

4.5.3 Execution

4.5.3.1 Installation

(1) Installation shall be followed instruction manual from manufacturer.

(2) The linear heat detection cables for each detection zone shall be installed in continuous runs without taps or branches in accordance with applicable sections of NFPA 70 and NFPA 72.

4.5.3.2 Testing and Commissioning

(1) Hydrant Test

(a) Each hydrant shall be fully opened and closed under system water pressure.

(b) Dry barrel hydrants shall be checked for proper drainage.

(c) The tests shall be completed with the pumps running.

(2) Control Valves Test

All control valves shall be fully closed and opened under system water pressure to ensure proper operation.

(3) Hose Connection and Fire Department Connection Test

All hose connection and fire department connection threads shall be tested to verify their compatibility with threads used by the local fire department. The test shall consist of threading coupling samples, caps, or plugs onto the installed devices.

(4) Manual Valve Test

Each valve intended to be manually opened or closed shall be operated by turning the hand-wheel crank or wrench for its full range and returning it to its normal position. Hose valve caps shall be tightened sufficiently to avoid leaking during the test and removed after the test to drain water and relieve pressure.

(5) Pressure Reducing Valves

(a) Each pressure-reducing valve shall be tested upon completion of installation to ensure proper operation under flow and no-flow conditions.

(b) Testing shall verify that the device properly regulates outlet pressure at both maximum and normal inlet pressure conditions.

(c) The results of the flow test of each pressure-reducing valve shall be recorded on the Private Party's test certificate.

(d) The results shall include the static and residual inlet pressures, static and residual outlet pressures, and the flow rate.

(6) The Foam Spray Set and Foam Fire Hose Set

Test and Commissioning the system real discharge test for checking the percent concentration of foam solution.

4.6 FIRE ALARM SYSTEM

4.6.1 General

4.6.1.1 General Requirement

(1) The fire alarm system shall be fully analog addressable, pre-signal, non-coded system in accordance with NFPA and shall be in compliance with UL listed and FM approved.

(2) The Private Party shall furnish and install the fire alarm system and equipment as specified hereafter and as approved by the Engineer’s Representative at the detail design stage.

4.6.1.2 Standard and Reference

The fire alarm system shall comply with the following codes and standards.

(1) NFPA 72 : National Fire Alarm Code

(2) NFPA 70 : National Electrical Code

(3) UL 38 : Manual Signaling Boxes for Fire Alarm Systems

(4) UL 268 : Smoke Detectors for Fire Alarm Systems

(5)	UL 268A	:	Smoke Detectors for Duct Application
(6)	UL 464	:	Audible Signal Appliances
(7)	UL 521	:	Heat Detectors for Fire Protective Signaling Systems
(8)	UL 864	:	Control Units and Accessories for Fire Alarm Systems
(9)	UL 1638	:	Visual Signaling Appliances - Private Mode Emergency and General Utility Signaling
(10)	UL 1971	:	Signaling Devices for Hearing Impaired
(11)	Factory Mutual (FM)		
(12)	IEC 60331	:	Tests for electric cables under fire conditions - Circuit integrity
(13)	IEC 60332	:	Tests on electric and optical fibre cables under fire conditions
(14)	IEC 61034-2	:	Measurement of smoke density of cables burning under defined conditions - Part 2: Test procedure and requirements
(15)	IEC 60754-2	:	Test on gases evolved during combustion of materials from cables – Part 2: Determination of acidity (by pH measurement) and conductivity
(16)	BS 6387	:	Test method for resistance to fire of cables required to maintain circuit integrity under fire conditions
(17)	IEC 60529	:	Degree of protection provided by enclosures (IP Code)
(18)	NEMA ANSI C80.6	:	Electrical intermediate metal conduit (IMC)

4.6.1.3 Submittals

(1) The material lists and technical data, Working Drawings, details of all material and equipment installations, and control logic shall be submitted to the Engineer’s Representative for approval before giving the manufacturer a purchase order and installation.

4.6.1.4 Quality Assurance

(1) The equipment manufacturer must specialize in the specified equipment and having experience about the equipment which have been installed in Thailand at least five (5) years.

(2) The equipment manufacturer shall be ISO 9001 certified.

4.6.1.5 Warranty

(1) All parts of the system including its performance shall be guaranteed by the manufacturer and/or the Private Party at least two (2) years after handover.

4.6.2 Materials

4.6.2.1 Description

(1) The fire alarm system shall be a fully analog addressable system whereby detection and alarm call points are loop-wired, giving fully analog output signals representing the true values of sensed phenomena to the control panel which incorporates intelligence, to make the decision of fire (or fault) based upon the analog information received.

(2) The system shall be electrically supervised for all initiating signal circuits, alarm notification signal circuits and power supply circuits.

(3) The addressable loops connecting addressable detectors, monitor modules, control modules, output modules, relay modules and line isolators to the fire control panel shall be wired in loops to form “Class A” or full duplex configuration. Line isolators shall be provided to isolate damaged parts of the cable loop and reduce to two wire half-duplex configuration when one of the paths has failed.

(4) Wiring from initiating devices (manual stations) and alarm notification devices to modules shall be wired in form of a “Class A” (4 wires).

(5) The fire alarm system shall be able to interface the following other system:

(a) Firefighting water flow alarm switches (for monitoring of activated status).

(b) Firefighting supervisory switches (for monitoring of activated status).

(c) Escalator Sprinkler Protection Systems; ESPS (for monitoring of alarm activated status).

(d) FM200 agent fire suppression systems (for monitoring of alarm activated status).

(e) Deluge pre-action system (for monitoring of alarm activated status).

(f) Diesel engine and electric fire pump control panels (for monitoring of activated status).

(g) Lifts/Escalators (for sending the evacuation signal to lift/escalator control panels for shutting down the operation in the event of evacuation).

(h) Building Management System; BMS (for sending the system status and alarm signals to BMS for monitoring).

(i) SCADA (for sending the system status and alarm signals to SCADA for monitoring at Operation Control Center; OCC).

(j) Station centralized master clock system (for synchronization of Date & Time).

(k) Automatic Fare Collection System; AFC (for sending the evacuation signal to the system).

(l) Public Address System (for sending the evacuation signal to the system).

4.6.2.2 Component

(1) Fire Alarm Control Panel (FCP)

(a) The fire alarm control panel shall be fully analog addressable, microprocessor based with provisions for monitoring addressable devices using plug-in zone P.C.B. cards, complete with power supply, battery and charger. The panel shall be a dead-front, heavy gauge steel enclosure, console type.

(b) The control panel shall have as a minimum 8 bit microprocessor base controlled by a program written in EPROM and shall be capable of receiving information from the detection devices such that each device can be uniquely identified and its alarm/non alarm state monitored.

(c) The approval standard of the control panel shall be UL 864 listed and FM approved.

(d) The following (LED) indicators and control switches shall be provided on the panel:

(i) Indicators:

- System ON
- System Fault/Failed
- Battery ON
- Alarm Condition
- Trouble Condition

(ii) Control switch:

- Reset
- Alarm acknowledge
- Alarm silence
- Trouble silence
- General alarm (evacuation)
- Lamp test

(e) The panel shall contain an integral back-lit LCD display which is visible through the panel door.

(f) The LCD display and printer programming shall be accomplished on-site by means of a handheld computerized device that shall plug into the panel.

(g) Programming functions shall include alarm/trouble type assignment, point descriptor assignment and alarm message assignment. Data files for the LCD display shall be stored in EPROM.

(h) The panel shall monitor the links with all detectors and sensors continuously. Upon actuation of one of the detectors or sensors, the LCD display shall indicate the ID number of the activated device, the appropriate status, the current time and date and the appropriate massage within the beginning of display lines. An alarm with buzzer and flashing LED shall be activated until acknowledged. The loss or failure of any device or sounder shall be identified and presented as a fault within 60 seconds.

(i) The FCP shall incorporate indicator lamps covering system fault, device fault, external fault, processor fault and device isolated.

(j) Actuation of one sensor in a loop should not cause the loop to be disabled for a late coming alarm signal from other sensors. If a next alarm is queuing, a “Next Alarm” LED should be lit on the panel and can be displayed on the display by pressing the “acknowledge” switch. However, the appropriate LED on the graphic annunciator panel shall flash once the alarm is received.

(k) The number of current fire alarms, unacknowledged alarms, trouble conditions and other miscellaneous alarms in the system shall be indicated in the end display line of the LCD display and a hard copy printed out from the printer. Text in English will be required.

(l) The status of the smoke and heat detectors shall be indicated on the panel showing the alarm condition and the area where the detector is located. A pre-alarm signal shall be generated for warning purposes if the detector condition deteriorates.

(m) Adequate communication ports and auxiliary contacts shall be provided with the FCP for interfacing with other system.

(2) Annunciator Panel

(a) The annunciator panel shall be of the surface mounted panel board with graphic representation of the location or zone of fire upon operation of a manual or automatic detector.

(b) The panel shall be fabricated from stainless steel sheets in standard frame dimension of A1 paper (840 (W) x 594 (H) mm approx.), completed with recess hinges and flush-key lock.

(c) The graphic shall take the form of a scaled drawing or drawings of the building in which the system is installed, mounted in one framed and glazed enclosure.

(d) The LED display lamp shall be provided on the panel for each fire compartment (zone) as created on the detector loops.

(e) A lamp test push button shall be provided.

(f) The panel shall possess an internal buzzer which shall operate in cases of fire and fault.

(3) Alarm Report Printer

(a) The printer shall be a dot-matrix printer type, 80 characters per line and use standard pin-feed paper. The printer shall be enclosed in separate cabinet suitable for placement on a desk top or table. The printer shall communicate with RS-232.

(b) The printer shall provide hard-copy print-out in status of all event changed in status of the system and shall time-stamp such print-outs with the current time of day and date.

(4) Power Supply

(a) Source of power supply

(i) The electrical power for fire alarm system shall be supplied through battery charger unit which interconnected with 24 volts dc standby batteries and 220 volt 50 Hz mains supply voltage fed from very essential power source.

(ii) The isolating protective device shall be colored/painted red and labeled "FIRE ALARM : DO NOT SWITCH OFF". Additional warning labels shall be provided where necessary in accordance with the Power Supplies section of NFPA 70 and 72. Fire alarms having more than one source of power supply shall be provided with additional precautionary labels in compliance with the above Codes.

(b) Standby batteries

(i) The standby batteries shall be of the maintenance-free sealed lead-acid type.

(ii) Suitable links shall be provided to facilitate the removal of cells for maintenance or replacement, without interrupting the supply from the charger or to the fire detection/alarm system.

(iii) A separate batteries and charger unit shall be provided in a metal cabinet.

(iv) The batteries capacity shall be adequate for maintaining the system in normal working condition for at least 24 hours during main power supply failure and subsequently to operate in the “alarm” condition for at least 15 minutes.

(v) The batteries shall be brought from fully discharged to fully charged condition within 48 hours.

(c) Battery Charger

(i) The charger shall be trickle type battery charger, suitable for use on a 240 V, 50 Hz single phase supply and is to automatically maintain the 24 V batteries in a state approximate to full charge and at the same time compensate for the standing load.

(ii) The charger shall incorporate the following devices:

1) An indicator lamp to show that the mains supply is healthy

2) A dc voltmeter to show the battery supply is healthy

3) A milli-ammeter to indicate charging current

4) Suitable fuses to protect the equipment

5) Auxiliary contacts for SCADA monitoring

(5) Initiating Devices

(a) Heat Detectors

(i) Automatic heat detectors shall be of the analog addressable type using the latest algorithm principles for accurate indication of normal condition, pre-alarm and alarm indications, complete with plug-in base and auxiliary contacts.

(ii) The heat detectors shall be of the combination fixed and rate-of-rise sensors. The fixed temperature setting shall be 57°C (135°F) and rate-of-rise temperature setting shall be 9°C (15°F) per minute.

(iii) The detectors shall comply with the applicable requirements of UL 521.

(b) Smoke Detectors

(i) Automatic smoke detectors shall be of the analog addressable type, using the latest algorithm principles for accurate indication of normal condition, pre-alarm and alarm indications, complete with plug-in base and auxiliary contacts.

(ii) The smoke detectors shall be of the photo-electric type operated on the light scattering principle utilizing a solid-state infrared LED and high speed, light sensing photo diode within its sensing chamber to detect visible products of combustion.

(iii) The detectors shall incorporate a built-in indicating red LED that shall flash in normal state and grow steady in alarm state.

(iv) The detectors shall comply with the applicable requirements of UL 268.

(c) Manually Actuated Alarm-Initiating Devices (Manual Stations)

(i) The manual stations shall be of the pull-down operation (double action), semi-flush mounted type with break-glass and a key for alarm reset.

(ii) The manual stations shall be arranged to operate automatically upon breaking of the glass and pulling down the handle. The glass panel shall be clipped firmly into place. The unit shall be of pleasing appearance and styling, constructed of non-corroding materials and finished in red. The words: "in case of Fire Break Glass and Pull down Handle" shall be displayed upon the front in both Thai and English.

(iii) The units shall be manufactured in bright red compliant material with working on method of operation in white lettering; the cover shall be etched in black lettering in Thai and English "FIRE".

(iv) The glass shall be of the pre-weakened, frangible non-splintering type with a protective plastic coating to prevent operator injury during and after breaking.

(v) The manual stations shall incorporate a test facility for simulating a breakage of the glass for system test purposes. It shall be possible to test without removing the cover or opening the point.

(vi) One spare glass shall be provided for each break-glass unit installed.

(vii) The manual stations will mechanically latch upon operation and remain so until manually reset by authorized personnel opening with a key which is a common key for all the station locks.

(viii) The stations shall comply with the applicable requirements of UL 38.

(6) Alarm Notification Appliances

(a) The alarm notification appliances shall be of the combination of audible/visible alarm devices; recess mounted and shall be colored red.

(b) The audible alarm devices shall be of the piezoelectric mini horn producing high sound level (minimum 85 dBA at 10 feet) and in compliance with the applicable requirements of UL 464.

(c) The visible alarm devices shall be xenon strobe light flash with clear lens. The rated strobe output shall be 15/75 candela peak power in compliance with the applicable requirements of UL 1971/UL 1638 consequently. The strobe flash rate shall be 1-2 flash per second.

(7) Interfacing Relays

Signals to control other systems by means of dry contacts shall be equipped with a 24V dc relay, with dry contact rating not less than 2 A. Final contact requirement to be agreed in interface coordination.

(8) Fireman's Telephone Intercommunication

(a) The act of plugging a handset into an emergency phone jack or removal of any phone from its normal hook position shall cause the appropriate phone location LED to flash and a distinctive audible device to sound at the control panel.

(b) The subsequent picking up of the master phone and acknowledgment of the proper phone circuit shall silence the pulsing tone and cause the phone location LED to stop flashing and remain on. This action shall couple the remote phone to the master phone to provide direct and private communications.

(c) A master telephone control module shall be furnished to provide processing of all two-way communication function. This module shall include an audible alert for call and trouble signaling a trouble silence switch with ring-back, a trouble indication and supervising monitor circuit.

(d) A master telephone control module including with Firemen's telephone handsets in the cabinet shall be installed adjacent to the FCP.

(e) Each emergency phone jack shall be provided and installed adjacent to each manual station. The cover plate of phone jack shall be stainless steel.

(f) One set of portable telephone handset shall be furnished for communication between the FCP in control room and the position of firefighter's telephone outlets in case of fire. The telephone handset shall be completed with 1500 mm coiled cord and single pole phone jack.

(9) Wiring System

(a) Recommendation of signal cables:

(i) Twisted-pair with shielded Fire Resistant cable for main control loop and in accordance with manufacturer's recommendation.

(ii) 2.5 mm^2 Fire Resistant cables for power distribute, along with the main control loop, to addressable devices.

(ii) 1.5 mm^2 Fire Resistant cables for manual stations (conventional type) link to addressable modules.

(iii) 2.5 mm^2 Fire Resistant cables for alarm notification appliances (conventional type) link to addressable modules.

(iv) 0.75 mm^2 Fire Resistant cables for Firefighter's telephone jacks link to addressable modules.

(v) 1.0 mm^2 Fire Resistant cables for interfacing relays (or auxiliary contacts) link to other systems as specified.

(b) All signal cables shall be installed in conduits. Supply and return lines must be in separate conduits.

4.6.2.3 Control Logic

(1) Should a fire be detected either by smoke detector; heat detector; firefighting flow switch; gaseous extinguishing system or a break glass unit, the following operation sequence shall be executed.

(2) General alarm; a system general alarm will include the following:

(a) Indicate the general alarm at FCP and annunciator.

(b) Identify the device that is the source of alarm zone at FCP and annunciator.

(c) Initiate all alarm notification appliances.

(d) Alert operation central at OCC via the SCADA system.

(f) Monitor operation of automatic fire suppression systems.

(g) Initiate operation of automatic public address alarm message.

(h) Allow AFC gates to open on transmission of evacuation signal.

(i) Give control signals to lifts control panels.

(j) Give control signals to escalator control panels

(k) Report the event on the system printer.

(3) When a trouble condition is detected by one of the system initiating devices, the following functions shall immediately occur at the control panel and annunciator.

(a) The system trouble LED indicator shall flash.

(b) A local sounding device in the panel shall be activated.

(c) The system CPU & LCD shall indicate all pertinent information associated with the trouble condition and its location. However, unacknowledged alarm message shall have priority over trouble messages.

(d) The appropriate message shall be reported via printer.

(e) The system trouble indicator on remote annunciators shall be illuminated.

(4) Activation of the “Acknowledge Switch” of the control panel shall silence the panel sounding device and change the “System Alarm” or “Trouble LED” from flashing to a steady “ON” condition. In case additional new alarm or trouble conditions exist in the system, activation of this switch shall advance

the display to the next alarm or trouble condition that exists, and shall not silence the local audible device or change the flashing LED to steady "ON" until all new conditions have been so acknowledges. New alarm conditions shall always be displayed before new trouble conditions. Activation of the acknowledge switch shall also cause a corresponding (time stamped) message to be print out. Occurrence of a new alarm or trouble condition shall cause the panel to "Resound" and again repeat the sequence.

(5) Activation of the "Signal Silence Switch" shall cause all appropriate indicating appliances and relays to return to the normal condition after and alarm condition. The selection of indicating circuits and relays silenced by this switch shall be fully programmable and changeable in the field.

(6) Activation of the "System Reset Switch" shall cause all electronically-latched initiating devices or zones, as well as all associated output devices and circuits, to return to the normal state. If alarm conditions still exist in the system after the "System reset Switch" activation, the system shall then re-sound the alarm conditions.

(7) Activation of the "Test Switch" of the system shall initiate an automatic test of all intelligent detectors in the system. Such test shall activate the electronics in each intelligent device, simulating an alarm condition. A report summarizing the results of this test shall be displayed automatically on the front panel, as well as on any LCD or printer of the system.

(8) Activation of the "Lamp Test Switch" shall turn "ON" all LED indicators.

(9) Input signals other than from detectors, sprinkler flow switches, and break glass units, and gaseous extinguishing system shall only generate an indication and buzzer alarm but shall not generate a general alarm.

(10) No general alarms to be sounded in passenger areas, to avoid panic. Alarms shall alert staff in control rooms and offices.

(11) From any manual station, authorized personnel with special keys may reset evacuation alarm.

4.6.3 Execution

4.6.3.1 Installation

(1) The Private Party shall install the fire alarm system in accordance with approved Working Drawings and manufacturer's recommendation.

(2) All final connections, tests, adjustments and calibrations shall be made under the direct supervision of a factory-trained technician of the fire alarm system supplier.

4.6.3.2 Testing and Commissioning

(1) These shall prove that:

(a) All equipment cabling and distribution is electrically and mechanically safe.

(b) All exposed metal work is properly bonded and earthed in accordance with the requirements of the appropriate Statutory Requirements and that all connections and points required to be earthed for safe and satisfactory operation are properly earthed in accordance with the manufacturers requirements.

(c) All cables, cores and terminations are properly made off, secure, properly supported and correctly identified and colored.

(d) All phases, polarities, neutral and common connections are correctly switched as required, that power is correctly available at all points and that voltage and frequency at all equipment is correct and in accordance with the requirements for correct working.

(e) All supplies are properly fused, or otherwise protected to give satisfactory discrimination and safe disconnection under fault conditions.

(f) All contacts are properly aligned and not subject to subject to excessive wear or erosion.

(g) All protective covers are properly fitted, all warning and designating labels are correct and in position and the inside of all boxes and cubicles are clean and free of "swarf" and cable striping.

(h) Batteries are properly ventilated, installed, connected and fitted, and that battery chargers are working correctly.

(i) Insulation resistance of all cabling and equipment is not less than that required by the requirements of the appropriate Statutory Authorities.

(j) All instruments and meters are energized with the correct polarity and working properly.

(k) All fault indications and alarms are working correctly.

(l) All essential equipment fed from battery systems continues to function correctly and without disturbance during all supply failures, restoration and standby sequences.

(2) Additional Tests

(a) Additional tests shall be performed to verify that the complete electrical installation shall meet the requirements of this Specification. The list provided below is indicative of the minimum tests required. This also includes the electrical services systems associated with mechanical services, fire protection systems, etc. The Private Party shall develop full test schedules for approval in accordance with the requirements of the Specification.

(b) Cables

(i) Continuity Test.

(ii) Insulation Resistance Test.

(iii) Earth Test.

(iv) Polarity Test.

(c) The Fire Detection & Alarm Systems will be tested in accordance NFPA 70 & 72. Each component and assembly will be type tested and functionally tested before installation, and the entire system functionally tested for correct operation including all interfaces with the other systems.

(d) Minimum required tests are as follows:

(i) Verify that the control unit is in normal condition as detailed in the manufacturers operation and maintenance manual.

(ii) Test initiating and indicating circuits for proper signal transmission under open circuit conditions. One connection each should be opened at not less than 10 percent of the initiating and indicating devices. Observe proper signal transmission according to class of wiring used.

(iii) Test each initiating and indicating device for alarm operation and proper response at the control unit. Test smoke detectors with actual products of combustion.

(iv) Test the system for all specified functions according to the approved operation and maintenance manual. Systematically initiate specified functional performance items at each station, including making all possible alarm and monitoring initiations and using all communications options. For each item, observe related performance at all devices required to be affected by the item under all system sequences. Observe indicating lights, displays, signal tones, and annunciator indications. Observe all voice audio for routing, clarity, quality, freedom from noise and distortion, and proper volume level.

(v) Test both Primary and Secondary Power: Verify by test that the secondary power system is capable of operating the system for the period and in the manner specified.

(e) Complete testing of automatic and manual fire alarm system.

4.7 GAS SUPPRESSION SYSTEM

4.7.1 General

4.7.1.1 General Requirement

(1) The Private Party shall furnish and install the gas suppression system as shown on specified herein.

(2) Supply and installation of the IG-100 system shall be carried out by a specialist sub-contractor in accordance with latest NFPA 2001/2012 Edition.

(3) The systems shall be the specialist sub-contractor to provide calculation, detailed installation and supervise installation.

(4) The specialist sub-contractor shall furnish detailed brochures outlining the operation, recharge, service and maintenance of the system. In addition, the equipment manufacturers recommended spare parts lists with information regarding availability and ordering instructions shall be provided.

4.7.1.2 Standard and Reference

The design, equipment, installation, and testing shall comply with the following codes and standards.

(1) Fire Protection Association (NFPA)

NFPA 2001/2012	:	Standard on Clean Agent Fire Extinguishing Systems
NFPA 70/2012	:	National Electrical Code
NFPA 72/2012	:	National Fire Alarm Code

(2) Underwriters Laboratories, Inc. (UL)

UL 38	:	Manual Signaling Boxes for Fire Alarm Systems
UL 217	:	Safety Single and Multiple Station Smoke Alarms
UL 268	:	Safety Smoke Detectors for Fire Protective Signaling Systems
UL 464	:	Audible Signal Appliances
UL 864	:	Control Units and Accessories for Fire Alarm Systems
UL 1971	:	Safety Signaling Devices for Hearing Impaired
UL 2166	:	Halocarbon Clean Agent Extinguishing System Units

(3) American Society of Mechanical Engineers (ASTM)

ASTM A53	:	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

(4) U.S. Department of Transportation (D.O.T.)

(5) Canadian Transport Commission (C.T.C)

(6) EU Standard in Transportable Pressure Equipment Directive (T.P.E.D)

(7) Factory Mutual (FM)

(8) Verband der Sachversichererl (VdS)

4.7.1.3 Submittals

The Following shall be submitted for approval prior to the start of the installation.

(1) All drawings and complete hydraulic flow calculation sheets from a UL 2166 listed computer program shall be submitted for review prior to installation.

(2) Drawings showing system and remote component locations, piping isometrics, electrical diagrams, elevations, and components detail.

(3) Invoice & Packing List from manufacturer.

(4) Manufacturer's data sheets on all components included in the system.

(5) Manufacturer's training, instructional manuals for the installing Private Party's personnel assigned to install this system.

(6) As build drawings submitted for review and approval, prior to project completion.

4.7.1.4 Warranty

(1) All IG-100 system components furnished under this PPP Contract shall be guaranteed against defective design, materials, and workmanship for the full warranty period, which is standard with the manufacturer and/or supplier, but in no case less than 2 years from the date of the system acceptance.

4.7.2 Materials

4.7.2.1 Description

(1) The extinguishing agent shall be IG-100, Nitrogen (N2).

(2) All materials and equipment furnished by the Private Party shall be of new, unused, and undamaged condition in strict accordance with the requirements of this specification.

(3) IG-100 fire suppression systems shall be of the engineered, permanently piped, fixed nozzle type.

(4) Systems shall be operated with a restorable electric actuator and incorporate a manual mechanical actuator.

(5) Detection systems shall be suitable for direct interface with the IG-100 fire suppression system. Detection networks shall be cross-zones.

(6) The systems shall be designed for total flooding and based upon the enclosure being sufficiently tight against agent leakage with all ventilation shut down and/or fire damper to provide for static air condition upon discharge.

(7) Agent quantity calculations shall be determined from dimensions furnished on the construction drawings for a design concentration of 38.8% at the anticipated hazard temperature of 20 °C.

(8) The system shall be designed to discharge the calculated agent quantity within 60 seconds period.

(9) Nozzle spacing shall be in accordance with the listed or approved coverage for each nozzle type. In all cases, the need for additional nozzles shall be considered based upon site conditions and manufacturers recommendations.

(10) The system operation shall be available for both Automatic and Manual.

(11) Automatic operation of each protected area shall be as follows:

(a) Actuation of 1 detector, within the system, shall:

(i) Energize an alarm bell and/or an optional visual indicator.

(ii) Transfer auxiliary contacts which can perform auxiliary system functions such as:

- Operate door holder/closures on access doors
- Transmit a signal to a fire alarm system
- Shutdown HVAC equipment.

(b) Actuation of a 2nd detector, within the system, shall:

(i) Energize a pre-discharge horn/strobe device.

(ii) Start time-delay sequence (not to exceed 60 seconds).

(iii) System abort sequence is enabled at this time.

(c) After completion of the time-delay sequence, the IG-100 Clean Agent system shall discharge and the following shall occur:

(i) Energize a visual indicator outside the hazard in which the discharge occurred.

(d) The system shall be capable of being actuated by manual discharge devices located at each hazard exit. Operation of a manual device shall duplicate the sequence description above except that the time delay and abort functions shall be bypassed. The manual discharge station shall be of the electrical actuation type and shall be supervised at the main control panel.

(12) Manual operation shall be available for both Manual Release and Manual Cylinder.

(a) Manual Release

(i) Energize a pre-discharge horn/strobe device.

(ii) Shut down the HVAC system and/or close dampers.

(iii) The IG-100 clean agent system shall discharge.

(b) Manual Cylinder

(i) The IG-100 clean agent system shall discharge.

(ii) Energize a pre-discharge horn/strobe device.

(iii) Shut down the HVAC system and/or close dampers.

4.7.2.1 Component

(1) IG-100 Control Panel

(a) The control panel is an electric automatic control releasing device for actuating a fire suppression system upon receipt of detection input signals. It shall be capable of handling hazards with cross-zoned detection.

(b) The control panel for FM-200 shall consist of the specified input (detection), output (signaling), power and control circuits, all connected to the function panel, equipped with the specified input and output circuit modules, and installed in one or more specified equipment cabinets.

(c) Operating power for the control panel shall be at 24 volts DC, derived from 220 volts 50 Hz feed from the station very essential supply.

(d) The panel shall contain a sealed lead-acid battery and automatic battery charger to give 24 hours standby power, arranged to come into use automatically in the event of a fault on the main incoming feed. Loss of the main feed shall initiate an alarm. Upon restoration of the main feed, the panels shall revert to normal operation.

(e) The panel shall incorporate the necessary interface points for the closing of dampers on Ancillary Supply and Dirty Extract duct branches, and the shut down of the local cooling systems, where applicable. The panel shall also contain contacts for the remote indicating to the Fire Alarm Panel of the following:

(i) Power supply healthy/fail.

(ii) Gas discharge.

(iii) Common fault alarm.

(f) LED indicators shall be provided on the front cover to annunciate the following condition.

(i) Normal

(ii) Trouble

(iii) Alarm

(iv) Pre-discharge

(v) Discharge.

(g) Control panel shall be UL 864 listed and FM approved.

(2) Agent (IG-100)

(a) The extinguishing agent shall be IG-100, Nitrogen (N_2).

(3) Agent Storage Containers

(a) IG-100 agent storage containers shall be of alloy steel construction in accordance with D.O.T., C.T.C., T.P.E.D or similar design clean agent containers specification, and finished in baked red enamel paint.

(b) Initial filling and recharge shall be done in accordance with the manufacturers established procedures and shall not require replacement components for normal service.

(c) Container assemblies shall be vertical, free standing modules employing suitable wall-mounted retaining brackets.

(d) Nameplates indicating manufacturers name and part number, agent fill weight, total charged weight, date of fill shall be permanently bonded to each container.

(e) Each container shall have the means to accommodate lifting devices to facilitate weighing, removal and replacing.

(f) Tank assembly shall have a pressure gauge and low pressure switch to facilitate continuous supervision of tank pressure.

(g) Liquid Level Measuring Device shall be installed as required by the manufacturer’s installation standard for agent storage container.

(h) Agent storage tank assemblies shall be UL Listed or FM approved or VdS certified.

(4) Pressure Regulator

(a) Working pressure 300 bar.

(b) Max inlet pressure 360 bar.

(c) Static outlet pressure 60 bar.

(d) Pressure regulator shall be separated from the cylinder valve for refilling services and shall not be required replacement components for refilling services.

(e) Pressure regulators shall be UL Listed or FM approved or VdS certified.

(5) IG-100 Actuators

(a) Discharge of IG-100 agent shall be released by rupture disc or valve actuators that mount directly on the container head, operated both electrically or manually.

(b) All actuators shall be UL listed or FM approved or VdS certified.

(6) Discharge Nozzles

(a) IG-100 discharge nozzles shall be of one piece aluminum or brass construction sized to provide flow rates in accordance with system design hydraulics.

(b) Orifices shall be machined in the nozzle body to provide a horizontal discharge in 180° or 360° patterns based upon the approved coverage arrangements.

(c) Nozzles shall be permanently marked with the manufacturers part number, number of orifices and orifice code.

(d) Nozzles shall be UL listed or FM approved or VdS certified.

(7) Smoke Detectors

(a) Smoke detectors shall be Photoelectric smoke detector, Plug-in, Low Standby Current.

(b) Smoke detectors shall be UL 268 listed and/or FM approved.

(8) Abort Station

(a) Abort station shall be Push & Hold.

(b) The abort station shall be UL 864 listed and/or FM approved.

(9) Manual Station

(a) The manual station shall be a push button switch and pull handle type (dual action) within key-lock for reset or test.

(b) Manual station shall be UL 38 listed and/or FM approved.

(10) Alarm Bell

(a) Electric alarm bell shall be Ø150 mm. (6”) with 24 VDC.

(b) The bell alarm sound level shall not be less than 80 dBA at 3 m.

(c) The housing shall be a high quality die casting with a baked red finish.

(d) The alarm bell shall be UL 464 listed and/or FM approved.

(11) Strobe Horn

(a) The horn sound level shall not be less than 90 dBA at 3 m.

(b) The strobe intensity shall be 75 candela (cd) at 15 m., flash rate shall be 1 flash per second minimum.

(c) The strobe horn shall be UL 1971 listed and/or FM approved.

(12) Selector Valves

(a) Selector Valve and actuator assembly to isolate separate protection zones from the same cylinder rack.

(b) Actuates system discharge electronically voltage 12-24 V AC/DC or manually

(c) Working pressure : 100 bar

(d) Type : Ball valve 2 way

(e) Material : Carbon Steel

(f) Selector valves shall be UL listed or FM approved or VdS certified.

(13) Warning Signs

(a) Etched aluminium warning signs shall be provided at all entrance and exits of the protected area.

(b) Entrance sign shall read: “WARNING - DO NOT ENTER ROOM WHEN ALARM SOUNDS, NITROGEN BEING RELEASED” in English and Thai.

(c) Exit sign shall read: “WHEN ALARM SOUNDS, VACATE AT ONCE, NITROGEN BEING RELEASED” in English and Thai.

(14) Pipe Material

Distribution piping shall be Schedule 40 steel pipe, ASTM. A53, GRADE B, SEAMLESS.

(15) Fittings

Fittings shall be Class 300 malleable or ductile iron.

4.7.3 Execution

4.7.3.1 Installation

(1) General

(a) The installation shall be made in accordance with the specifications and applicable NFPA 2001 and NFPA 72.

(b) Install equipment in accordance with manufacturer’s instructions.

(2) Piping Installation

(a) Welding methods shall be used.

(b) Piping must be reamed, blown clear, and swabbed with appropriate solvents to remove burrs, mill varnish, and cutting oil before assembly.

(c) The piping network shall be free of particulate matter and oil residue before installation of nozzles.

(d) Teflon tape dope shall be used, and shall be applied to male threads.

(e) All piping mush be solidly anchored to wall, building structure, etc., for support and thrust block.

(f) Pipes shall prime coat for rust prevention and finishing coat with red colour.

(3) Equipment and Accessories

(a) Agent storage containers shall be securely mounted to the structural frame. The mounting stainless steel bracket which bands formed to the radius of cylinders with flange for bolting to continuous slot metal framing channel of 12 gauge steel with galvanized. Surface shall be capable of withstanding a load up to 5 times the cylinder weight.

(b) All agent storage containers shall be centrally located as vertical, free-standing cylinders with wall mounted retaining brackets.

(c) The nozzle shall be threaded directly to the discharge piping without the use of special adaptors.

(4) Wiring

All wiring associated with the alarms shall be carried out in IMC conduit.

4.7.3.2 Testing and Commissioning

(1) Installation Acceptance

(a) Adequate quantity of agent to produce the desired specified concentration shall be provided. The actual room volumes shall be checked against those indicated on the system drawings to ensure the proper quantity of agent. Fan shutdown and damper closure time shall be taken into consideration.

(b) The piping shall be pneumatically tested in a closed circuit for a period of 20 minutes at 150 psig . At the end of 20 minutes, the pressure drop shall not exceed 15 psig.

(c) All auxiliary functions such as alarm-sounding or displaying devices, remote annunciators, air-handling shutdown, and power shutdown shall be checked for proper operation in accordance with system requirements and design specifications. If possible, all air-handling and power-cutoff controls shall be of the type that, once interrupted, require manual restart to restore power.

(2) Preliminary Functional Tests

The following preliminary functional tests shall be provided:

(a) If the system is connected to an alarm receiving office, notify the alarm receiving office that the fire system test is to be conducted and that an emergency response by the fire department or alarm station personnel is not desired. Notify all concerned personnel at the end-user’s facility that a test is to be conducted and instruct personnel as to the sequence of operation.

(b) Disable each agent storage container release mechanism so that activation of the release circuit will not release agent. Reconnect the release circuit with a functional device in lieu of each agent storage container release mechanism. For electrically actuated release mechanisms, these devices can include 24-V lamps, flashbulbs, or circuit breakers. Pneumatically actuated release mechanisms can include pressure gauges. Refer to the manufacturer's recommendations in all cases.

(c) Check each detector for proper response.

(d) Check that polarity has been observed on all polarized alarm devices and auxiliary relays.

(e) Check that all end-of-line resistors have been installed across the detection and alarm bell circuits where required.

(f) Check all supervised circuits for proper trouble response.

(3) System Functional Operational Test

The following system functional operational tests shall be performed:

(a) Operate detection initiating circuit. Verify that all alarm functions occur according to design specification.

(b) Operate the necessary circuit to initiate a second alarm circuit if present. Verify that all second alarm functions occur according to design specifications.

(c) Operate manual release. Verify that manual release functions occur according to design specifications.

(d) Operate abort switch circuit if supplied. Verify that abort functions occur according to design specifications. Confirm that visual and audible supervisory signals are received at the control panel.

(e) Test all automatic valves unless testing the valve will release agent or damage the valve (destructive testing).

(f) Check pneumatic equipment, where required, for integrity to ensure proper operation.

(4) Remote Monitoring Operations.

The following testing of remote monitoring operations, if applicable, shall be performed:

(a) Operate one of each type of input device while on standby power. Verify that an alarm signal is received at remote panel after device is operated. Reconnect primary power supply.

(b) Operate each type of alarm condition on each signal circuit and verify receipt of trouble condition at the remote station.

(5) Control Panel Primary Power Source.

The following testing of the control panel primary power source shall be performed:

(a) Verify that the control panel is connected to a dedicated circuit and labeled properly. This panel shall be readily accessible, yet restricted from unauthorized personnel.

(b) Test a primary power failure in accordance with the manufacturer's specification with the system fully operated on standby power.

(6) Return of System to Operational Condition.

When all pre-discharge work is completed, each agent storage container shall be reconnected so that activation of the release circuit will release the agent. The system shall be returned to its fully operational design condition. The alarm-receiving office and all concerned personnel at the end-user's facility shall be notified that the fire system test is complete and that the system has been returned to full service condition.

(7) Commissioning

(a) Prior to final acceptance, the Private Party shall provide complete operation and maintenance instruction manuals to the SRT and Engineer's Representative. All aspects of system operation and maintenance shall be detailed, including electrical schematics of all circuits, a written description of the system design, drawings illustrating equipment location, and technical bulletins describing each component.

(b) The manufacturer shall provide a supplemental, maintenance, inspections, training seminar proposal for providing certification for SRT's technical personnel.

4.8 DELUGE FOAM SPRAY NOZZLE SYSTEM AND FOAM FIRE HOSE

4.8.1 General

The "Deluge Foam Spray Nozzle System and Foam Fire Hose" is designed for specific fire suppression requirement to DP08-HS, Hazardous Storage on Depot Platform, which store the flammable and explosive materials.

4.8.1.1 General Requirement

(1) The Private Party shall furnish and install the Foam Spray System and Foam Fire Hose system as specified herein.

(2) Supply and installation of the Foam Spray System and Foam Fire Hose system shall be carried out by a specialist sub-contractor in accordance with latest NFPA 16.

(3) The systems shall be the specialist sub-contractor to provide calculation, detailed installation and supervise installation.

(4) The specialist sub-contractor shall furnish detailed brochures outlining the operation and maintenance of the system. In addition, the equipment manufacturers recommended spare parts lists with information regarding availability and ordering instructions shall be provided.

4.8.1.2 Standard and Reference

The design, equipment, installation, and testing shall comply with the following codes and standards.

(1) Fire Protection Association (NFPA)

NFPA 13 : Standard for the Installation of Sprinkler System

NFPA 16 : Standard for the Installation of Deluge Foam-Water Water sprinkler and Foam-Water Spray system

(2) American Society of Testing and Material (ASTM)

(3) American National Standards Institute (ANSI)

4.8.1.3 Submittals

The Following shall be submitted for approval prior to the start of the installation.

(1) Drawings showing system and remote component locations, piping isometrics, elevations, and components detail.

(2) Manufacturer's data sheets on all components included in the system.

(3) As build drawings submitted for review and approval, prior to project completion.

(4) All drawings and complete hydraulic flow calculation sheets shall be submitted for review prior to installation.

4.8.1.4 Warranty

(1) All system components furnished under this PPP Contract shall be guaranteed against defective design, materials, installation and workmanship for the full warranty period of 2 years from the date of Completion.

4.8.2 Materials

4.8.2.1 Description

(1) All materials and equipment furnished by the Private Party shall be of new, unused, and undamaged condition in strict accordance with the requirements of this specification.

(2) The systems design of Deluge Foam Spray discharge density shall be in accordance with the applicable occupancy standard for foam water system but in no case less than 6.5 l/mim/sq.m. and foam solution discharge shall be designed for period of 15 min. For minimum flow rate for Foam fire hose shall be 190 l/min at 5 bars and foam solution discharge shall be designed for period of 15 min.

(3) Nozzle spacing shall be in accordance with the listed or approved coverage for each nozzle type. In all cases, the need for additional nozzles shall be considered based upon site conditions and manufacturers recommendations.

(4) The system operation shall be available for both Automatic (by Pilot Sprinkler) and Manual (by Mechanism Manual at Deluge Valve)

4.8.2.2 Component

(1) Deluge Valve and Hydraulic operate trim.

(a) Deluge valve shall be Hydraulic Operated type, made from ductile iron, grooved ends connection, working pressure 300 psi., UL/FM approved

(b) Deluge trim shall be comprised of Standard Hydraulic Trim, Alarm pressure Switch, Water motor gong.

(2) Ball valve (Inlet and Outlet of Deluge valve)

(a) Ball valve made from Brass, grooved ends connection, working pressure 350 psi., UL/FM approved

(3) Foam Spray Nozzle

(a) Foam Spray nozzles made from Bronze frame, Brass Deflector and stainless steel screen Mesh, working pressure 175 psi., K-factor = 40 (lpm/bar^0.5), UL approved.

(4) Line Proportioners

(a) Line Proportioners made from corrosion resistance brass, thread ends.

(b) Minimum inlet pressure shall be 5.4 bars.

(5) Foam Storage tank

(a) Foam Storage tank made from 316 stainless steel capacity 500 liters, complete with manhole, sight glass, Air Vacuum vent

(6) Foam Concentrate

(a) Foam Concentrate shall be Synthetic Foam Alcohol Resistance type, 3% concentrate, (3%-3% AR-AFFF).

(b) Specific Gravity 1.010 g/ml, pH 7.6, Viscosity < 3500 cps.

(c) UL approved.

(7) Valves in Suction Line of Foam Concentrate

(a) Valves shall be Ball valve and Check Valve type. Made from 316 stainless body.

(8) Pilot sprinkler Detector

(a) Pilot Sprinkler shall be quick response type, size ½" thread, K-factor = 80 (lpm/bar^0.5), 175 'F temperature, bulb type and Upright or Pendent style, made from brass and chrome finished, UL/FM approved.

(b) The pilot detector shall be protected from accidental damage by Sprinkler guards.

(9) Strainer

(a) Strainer shall be Y type, made from cast iron body and Stainless steel screen, working pressure.175 psi.

(10) Pipe Material

Distribution piping shall be Schedule 40 steel pipe, ASTM. A53, GRADE A or B, SEAM.

(11) Fittings

Fittings shall be Grooved or Thread or Weld.

4.8.3 Execution

4.8.3.1 Installation Acceptance

(1) The piping shall be Hydrostatic tested in a closed circuit for a period of 2 hours at 200 psig.

(2) All Equipment and Pipes shall be installed in good engineering practice and shall be inspected and accepted by Engineer's Representative.

4.8.3.2 Commissioning Acceptance

The Private Party shall provide at least but not limit to

(1) Test and Commissioning the system real discharge test for checking the percent concentration of foam solution and

(2) Complete operation and maintenance instruction manual including a written description of the system design, drawings illustrating equipment location, and technical bulletins describing each component.

(3) Operator training

4.9 ELECTRICAL AND CONTROL WORKS

4.9.1 General

4.9.1.1 General Requirement

(1) This part of the Specification describes all electrical equipment and installations including connections thereof for the aforementioned system.

(2) The Private Party shall furnish and install all equipment and accessories for the electrical and control works as per the detail design which shall be approved by the Engineer's Representative.

(3) Unless items are factory-finished, one prime coat shall be provided on all raceways, hanger assemblies, equipment and accessories furnished under this section. Prime coating on steel and iron shall be synthetic red lead, or other materials as directed by the Engineer's Representative.

(4) All equipment, wiring methods and the installation shall conform to the latest applicable standards as specified in this specification.

4.9.1.2 Standard and Reference

The electrical and control works shall comply with the following codes and standards.

(1) IEC 60228 : Conductors of insulated cables

(2) IEC 60502-1 : Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1.2 kV) up to 30 kV (Um = 36 kV) - Part 1: Cables for rated voltages of 1 kV (Um = 1.2 kV) and 3 kV (Um = 3.6 kV)

(3) IEC 60331-1 : Tests for electric cables under fire conditions - Circuit integrity - Part 1: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0.6/1.0 kV and with an overall diameter exceeding 20 mm

(4) IEC 60331-2 : Tests for electric cables under fire conditions - Circuit integrity - Part 2: Test method for fire with shock at a temperature of at least 830 °C for cables of rated voltage up to and including 0.6/1.0 kV and with an overall diameter not exceeding 20 mm

(5) IEC 60331-11 : Tests for electric cables under fire conditions - Circuit integrity - Part 11: Apparatus - Fire alone at a flame temperature of at least 750 °C

(6) IEC 60332-1-1 : Tests on electric and optical fibre cables under fire conditions - Part 1-1: Test for vertical flame propagation for a single insulated wire or cable – Apparatus

(7) IEC 60332-3-10 : Tests on electric and optical fibre cables under fire conditions - Part 3-10: Test for vertical flame spread of vertically-mounted bunched wires or cables – Apparatus

(8) IEC 61034-2 : Measurement of smoke density of cables burning under defined conditions - Part 2: Test procedure and requirements

(9) IEC 60754-2 : Test on gases evolved during combustion of materials from cables – Part 2: Determination of acidity (by pH measurement) and conductivity

(10) BS 6387 : Test method for resistance to fire of cables required to maintain circuit integrity under fire conditions

(11) ANSI/NEMA FB 1 : Fittings, Cast Metal Boxes and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable

(12) ASTM A123/A123M : Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

(13) ASTM D1248 : Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable

(14) NEMA ANSI C80.1 : Electrical rigid steel conduit (RSC)

(15) NEMA ANSI C80.3 : Steel electrical metallic tubing (EMT)

(16)	NEMA ANSI C80.6	:	Electrical intermediate metal conduit (IMC)
(17)	IEC 60529	:	Degree of protection provided by enclosures (IP Code)
(18)	NFPA 130	:	Standard for Fixed Guideway Transit and Passenger Rail Systems
(19)	NFPA 70	:	National Electrical Code
(20)	EIT 2001-56	:	Thai Electrical Code 2013
(21)	MEA	:	Metropolitan Electricity Authority

In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

The standards and codes as mentioned above can be equivalent by another standards and codes, if it equal or better than the standards and codes mentioned when comply between two codes.

4.9.1.3 Submittals

(1) The material lists and technical data, Working Drawings, details of all material and equipment installations, and catalog shall be submitted to the Engineer's Representative for approval before purchasing and installation.

4.9.1.4 Quality Assurance

(1) The equipment manufacturer shall be ISO 9001 certified.

4.9.1.5 Warranty

(1) All parts of the electrical and control works shall be guaranteed by the Private Party at least two (2) years after handover.

4.9.2 Materials

4.9.2.1 Description

(1) The provision and installation of the equipment shall be based on the following electrical system:

(a) Rated Voltage : 415-Y/240V

(b) System Voltage : 380-Y/220V

(c) Rated Frequency : 50 Hz.

(d) Earthing System : TN-S (separate neutral and protective conductors throughout the system)

(2) All electrical conductors such as busbars, cables, wires, terminals, etc. shall be color-coded in compliance with EIT 2001-56 std. as follows:

(a) Phase A (R) : Brown

(b) Phase B (S) : Black

(c) Phase C (T) : Gray

(d) Neutral : Light Blue

(e) Ground : Green or Green-with-Yellow strip

(f) Large wires and cables and shall be color-coded with suitable heat shrinkable sleeves as the specified color.

(g) Busbars shall be color-coded with standard paint as the specified color.

4.9.2.2 Component

(1) Earthing (or Grounding) & Bonding

(a) The equipment grounding system shall be designed and installed such that all metallic, enclosures, raceway, junction boxes, outlet boxes, cabinets, machine frames, portable equipment, and other conductive items in close proximity with electrical circuits operate continuously at ground potential.

(b) The equipment grounding system shall provide a low impedance path for possible ground fault currents. The system shall consist of a separate green insulated equipment grounding conductor for each feeder and each branch circuit. The required grounding conductor shall be installed in the common conduit with the related phase and/or neutral conductors. Each electrical expansion fitting shall be provided with an external flexible braided ground strap securely bonded on each end of the fitting. The required equipment grounding conductors shall be sized in accordance with NEC - Table 250.122 or/and EIT 2001-56 Section 4 or other approved equivalent.

(c) Unless otherwise specified, the grounding connectors shall be of a type specifically manufactured for grounding purposes, made of copper alloy and assembled with high strength silicon bronze hardware. Where grounding or bonding conductors connect to structural cables, connections shall be made with mechanical devices; welded connections shall not be made at these points. All mechanical connections shall be completely encapsulated in non-hardening, conductive epoxy. The epoxy shall be applicable for wet locations or for ambient temperatures of 10 °C - 55 °C.

(d) Jumper material shall be flexible braided tinned-copper strap.

(2) Low Voltage Cables

(a) General Requirement

(i) Power cables will be single, two, three or four conductors depending on the design in the detailed design stage which being used in a 3-phase - 4-wire - 50 Hz / TN-S system.

(ii) All cables shall be selected suitably for indoor and outdoor installations, wet and dry locations, exposed to sunlight, in conduit, in cable tray, in wireway as appropriate.

(b) Fire Resistant Cable: FR Cable

(i) Conductors shall be of soft or anneal uncoated stranded copper wire in accordance with IEC 60228.

(ii) Insulation shall be consisted of fire resistance tape (mica tape, etc.) cover the copper conductor and the outer shall be cross-linked polyethylene (XLPE) or polyolefin insulation which has thickness according to IEC 60502.

(iii) Outer sheath shall be of polyethylene or other material that have low smoke and zero halogen (LSF or LSOH or LSZH).

(iv) For multi-core conductor cable, the component of cable shall consist of Conductors (2 or 3 or 4 cores), Insulation, Filler, Binding Tape, and Outer Sheath. Filler shall be of low smoke/zero halogen material.

(v) Rated voltage of cable shall be 0.6/1.0 kV.

(vi) Cable shall not generate toxic gases in event burnt.

(vii) Standard for Testing of Fire Resistance shall be in compliance with BS 6387 Category C, W, Z or/and IEC 60331-1 / -2 / -11.

(viii) Standard for testing of flame retardant shall be in compliance with IEC 60332-1 / -3.

(ix) Standard for testing of smoke emission shall be in compliance with IEC 601034-2.

(x) Standard for testing of toxic gas emission shall be in compliance with IEC 60754-2.

(xi) Test reports shall be submitted for approval.

(xii) Cable fittings in each junction box shall be fire resistant type.

(3) Conduits and accessories

(a) Rigid Steel Conduit (RSC), if applied, shall be steel and galvanized by the hot-dip process in compliance with NEMA ANSI C80.1 and complete with enamel finished inside the tube.

(b) Intermediate Metal Conduit (IMC) shall be steel and galvanized by the hot-dip process in compliance with MENA ANSI C80.6 and complete with enamel finished inside the tube.

(c) Electrical Metallic Tubing (EMT), if applied, shall be steel and galvanized by the hot-dip process in compliance with NEMA ANSI C80.3 and complete with enamel finished inside the tube.

(d) Flexible Metal Conduit (FMC) shall be made from galvanized steel. The FMC installed in wet locations shall be of the liquid-tight type.

(e) Flexible conduit and fittings for life safety equipment shall be galvanized water-tight pattern, frame retardant; LSOH over-sheathed and separated earth wire enclosed within the conduit.

(f) Conduit fittings and conduit bodies shall be galvanized steel in compliance with ANSI/NENA FB 1 standard.

(g) The finished conduit and fittings shall have smooth surface for wire pulling, and shall not have any lumps of excess zinc and other injurious deflects to damage the wire.

(h) The outside surface and threads on conduit shall have protective coating against corrosion. The threads on the fittings shall have paint, zinc or other protective coating against corrosion.

(i) The standard manufactured Elbows shall be used for all sizes of conduits larger than 25 mm. (1 inch). The field bends to be handles with great care not to damage the conduits, will be permitted for conduit of 25 mm. (1 inch) and smaller.

(j) Conduit expansion joints shall be provided at building expansion joints. Metallic expansion fittings to ensure grounding continuity shall be applied.

(k) Conduits and accessories installed in all **Stations** shall be capable of being subject to temperatures up to 500^{O}C for 1 hour and shall not support combustion under the same temperature, in accordance with NFPA 130.

(l) The following table shall be the comparison of nominal diameters of conduit in inches and in mm.

Conduit Diameter in Inches	½	¾	1	1 ¼	1 ½	2	2 ½	3	3 ½	4
Conduit Diameter in mm	15	20	25	32	40	50	65	80	90	100

(4) Boxes and Accessories

(a) Outlet Boxes

(i) For wall/column recessed, the boxes shall be of steel sheet with not less than 1 mm thickness with hot-dip galvanized after fabrication, and completed with adjustable lug, ample knocked-holes and brass earth terminals fitted within the box.

(ii) For exposed works; the boxes shall be of die-cast aluminium, and completed with threaded hubs, neoprene gasket and earth terminal fitted within the box. The boxes shall be allowed for outdoor works in accordance with IP65 protection class.

(iii) The internal depth of a box shall be not less than 32 mm.

(iv) The corners of a box shall be mechanically and electrically continuous.

(b) Pull Boxes and Junction Boxes

(i) Pull boxes and junction boxes for branch circuits, indoor used, shall be as the same type of the outlet boxes and to be equipped with galvanized steel cover plate fastened with stainless steel screws.

(ii) Pull boxes and junction boxes for branch circuits, outdoor used, shall be of die-cast aluminium circular box completed with threaded hubs, earth terminal fitted within the box and fastening cover with neoprene gasket for IP65 protection class.

(iii) Pull boxes, which are used in feeder system (main feeders or feeders or sub-feeders), shall be made of steel sheet with not less than 1.6 mm thickness with hot-dip galvanized after fabrication, completed with ground flange, neoprene gasket and lid fastened with stainless steel screws. The boxes where used on outdoor location shall be IP65 protection class.

(iv) The corners of a box shall be mechanically and electrically continuous.

(v) Size of the pull boxes and junction boxes shall be selected in compliance with NFPA 70 and EIT 2001-56 standards.

4.9.3 Execution

4.9.3.1 Installation

(1) The Private Party shall install the Electrical and Control Works in accordance with the approved Working Drawings and manufacturer's instructions, and in compliance with the requirement of NFPA 70; EIT 2001-56; and the recommendation of MEA.

(2) All metal and non-carrying current parts shall be grounded.

(3) Low Voltage Cables

(a) In general, the Power cables shall be run in conduits, in cable tray and shall be run concealed in ceiling, floor, and wall or as indicated on the approved Working Drawings.

(b) No wire shall be pulled into the conduit system until it is complete in all details.

(c) Lubricant shall be used to facilitate wire pulling. Lubricants shall be approved for using with the insulation specified.

(d) Splicing of wires and cables shall be allowed only in the luminaires, receptacles and proper junction box with an approved method of insulation. No splice shall be made in conductors for instrument circuits or control circuits.

(e) Splicing of large wires and cables shall be by compression type, solderless wire connectors indented by special hydraulic tool. The splice shall be insulated with plastic insulation tape such as Scotch Brand No.35. Thickness of the tape shall not be less than three layers or at least the same thickness as the wire insulation.

(f) Compression type, solderless lugs indented by proper tool shall be used at the end of all wires and cables and shall be connected to the screw type terminals of the equipment and to the bus bars.

(g) The cut end of cables shall be treated to prevent seepage of water into the cable.

(h) The Private Party shall provide all necessary materials for installation of the cables, such as grounding lead wires, compression type terminals, metal fitting, bolts and nuts including cable identification and felt packing to be inserted between cable and cleats.

(i) The unoccupied space in cable knockouts and conduits after cable insertion shall be filled, with duct seal to prevent insects and small animals from entering the equipment housing.

(j) Where cables are buried in the ground the minimum depth of burial shall be 0.6 m. Cables shall be laid on 0.15 m and covered by a 7.5 cm. layer of clean sand. Cables shall be covered with tiles and or marking tape and the trenches backfilled to grade level.

(k) Cables under roads shall be enclosed in ducts supplied and installed by the electrical work.

(l) All cables shall be identified by means of cable tags fitted to each termination point and at 30 meter intervals along cable route.

(m) Cable route markers shall be installed above ground along underground cable routes. These shall be located at 30 meter inter- intervals, at changes of direction and at entries to buildings.

(n) The Private Party shall be responsible for the supervision of the cable trench excavation, sanding and backfilling, supply and installation to warning tape, cable tiles and cable marker posts as detailed on the approved Working Drawings and in these Specifications.

(o) Cables shall be laid in one continuous length.

(p) Conductors with compression type terminals and insulation cover shall be arranged in a neat manner on terminal box or equivalent terminals. The Private Party shall install plastic cable tie-wraps as required to neatly group cables and to keep the weight of the cable from damaging terminations.

(q) The conductors in vertical raceways shall be supported if the vertical rise exceeds the values in following table:

Spacing for Conductor Supports in Vertical Raceway		
Size of Cable (mm^2)	**Maximum Spacing (m)**	**Remark**
50 or smaller	30	If the vertical run is less than 25% of max. Spacing in table, cable supports will not be required.
70 thru 120	24	
150 thru 185	18	
240	15	
300	12	
over 300	10	

(4) Conduits & Accessories

(a) All conduits shall be as specified herein with a minimum size of 15 mm. unless otherwise noted.

(b) Where the conduits enter the cabinets and equipment, conduit bushings and double locknuts shall be used.

(c) The end of all conduits shall be tightly plugged to exclude dust and moisture while the buildings are under construction.

(d) The bending radius of the conduit shall not be less than six times the outer diameter of the conduits. The total bending angles of conduits shall not exceed 360 degrees in any one run.

(e) The conduits used shall not have any internal and external defects. Each end of the conduit shall be made smooth with the conduit reamer to prevent damage to the wire.

(f) A short piece of flexible metal conduit shall be used for connecting all motors, vibrating equipment, recess lighting fixtures and junction boxes and as otherwise specified.

(g) The wiring system shall consist of PVC insulated cables drawn into conduit. Wiring shall be loop-in style without joints.

(h) The wiring capacity of conduits shall conform to the requirement in EIT Standard 2001-56 and/or the current edition of NFPA 70.

(i) Conduit shall be run neatly on the surface or buried within the carcase of the buildings as indicated on the approved Working Drawings and in these Specifications. Conduit shall be run at least 0.15 m. clear of plumbing and mechanical services.

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

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

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

(m) Provide suitable fittings to accommodate expansion and deflection where conduit crosses seismic, control and expansion joints.

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

(o) The Conduits and termination boxes for Electrical and Control Works shall have to be painted strip color coding at interval 1 m along total length of raceways with;

(i) Normal Power : Orange

(ii) Essential Power : Yellow

(iii) Control system : Blue

4.9.3.2 Testing and Commissioning

(1) Low Voltage Cables

(a) All cables fed to the equipment shall be meggered phase-to-phase and phase-to-ground before the equipment is connected and phase-to-ground after the equipment is connected and all connection are tapped.

(b) Insulation resistance tests shall be performed by using a 500 Vdc megger on the 400 volts system. Insulation resistance shall be not less than one mega ohms per 1000 volts rating.

4.10 FIRE BARRIER WORK

4.10.1 General

4.10.1.1 General Requirement

(1) After erection of materials and equipment through wall and opening had been completed, it is the responsibility of the Private Party to fill up voids and openings with fire resistant materials which conform to NEC article 300-21 and ASTM to protect fire or smoke from spreading out from one room to another room through these voids and openings.

4.10.1.2 Standard and Reference

(1) The fire barrier material and it's accessories shall comply with the following codes and standards.

(a) NEC 300-21 : Spread of Fire or Products of Combustion

(b) ASTM E814 : Standard Test Method for Fire Tests of Through-Penetration Fire Stops

(c) UL 1479 : Fire Tests of Through-Penetration Fire Stops

(2) In the case of conflict or uncertainty in the application of the above standards and codes, the most stringent regulation shall govern.

(3) All regulations and standards shall be of the latest issue unless governing authorities require an earlier issue.

(4) The standards and codes as mention in (1) can be equivalent by another standards and codes, if it equal or better than standards and codes mention in (1) when comply between two codes.

4.10.1.3 Submittals

(1) The Private Party shall submit material selector, catalog, material lists, technical data and method of installation for approval before purchasing and installation.

4.10.1.4 Warranty

(1) All material and installation of the fire barrier work shall be guaranteed by the Private Party at least two (2) years after handover.

4.10.2 Materials

4.10.2.1 Description

(1) The applied to wall considered to be a fire or acoustical protection wall, unless otherwise specified. Cover or escutcheon plates shall be provided, wherever exposed, and shall be neatly placed to the satisfaction of the Engineer's Representative.

(2) The fire resistant rating of the material shall be in accordance with the fire rating of construction walls or slabs and shall be not less than 2 hours.

4.10.2.2 Component

(1) The fire barrier materials shall have properties as the following:

(a) The fire barrier materials shall be of a minimum 2-hours fire resistant rating or higher in accordance with type of construction walls or slabs.

(b) The fire barrier materials must not be toxic during installation or incase of fire.

(c) Easy to be dismantled and replaced in case of rearrangement.

(d) Withstand over vibration.

(e) Easy installation.

(f) Before and after fire spreads, the fire barrier materials must be strong enough.

4.10.3 Execution

4.10.3.1 Installation

(1) At every voids and openings, fire barrier materials shall be installed where:

(a) Every voids, sleeves, and openings appear on wall, floor, beam and shaft, provided for raceway and fire water piping installation, must be sealed after the erection work had been completed.

(b) Voids, sleeves, and openings which are provided for future installation.

(c) Voids between electrical conduits and sleeves.

(d) Voids between electrical cabling and raceway on fire wall and floor.

(e) Voids between raceway and sleeves on fire wall and floor.

4.10.3.2 Testing and Commissioning

(1) The testing method shall be provided from the manufacturer.

4.11 PAINTING

4.11.1 General

4.11.1.1 General Requirement

(1) Prior to equipment installation all metal surfaces shall be treated with anticorrosive materials and/or painted according to this specification.

(2) The preparation and application of the painting materials shall adhere strictly to the manufacturer's recommendations.

(3) The equipment or materials that have previously been treated with anticorrosive materials and painted from the factory must be inspected for their workmanship. Any defects, such as scratches, peels and rust shall be repaired and repainted to the approval of the Engineer’s Representative.

(4) During the progress of the paint work, the Private Party shall avoid spotting of the floors, walls and other adjacent equipment. All spotting, if any, shall be cleaned immediately. Any damages, which may result from painting shall be under the Private Party's responsibility.

4.11.2 Materials (Not used)

4.11.3 Execution

4.11.3.1 Painting

(1) Preparation and Cleaning of Surface to be Painted

(a) Metal or Ferrous Metal Surfaces

Rust at welding joints and other defects shall be removed by scraping. Wire brushes or sand papers shall be used to clean the surfaces and to remove rust. Sand-blasting may be used to remove loose rust and other foreign substances. Mordant solution such thinner, gas, terpentine shall be used to remove grease, oil or organic coating. Then the surface shall be cleaned with water and thoroughly dried or blow-dried.

(b) The application of prime coats which follows shall adhere strictly to the manufacturer's recommendations.

(c) Old paint coats shall be removed by scraping before application of new paint.

(2) Brush or Spray Painting

Each paint coat shall be left until completely dry before subsequent applications. Painting can be classified into 2 coats :

(a) Prime coat for rust prevention and/or adhesion of the finishing coats.

(b) Finishing coat for final appearance or for symbolizing the system codes. Types of paint used shall depend on the material as well as on the environment.

(3) Types of Paint for Various Surface and Environment

Type of Surface	Normal Area	Humid Area or Corrosive Area
Black steel pipe, Galvanize steel pipe, black steel hanger and support, black steel sheet, switchboard, and panel.	1st coat : Red lead primer 2nd coat : Red Lead primer 3rd coat : Alkyd finishing paint. 4th coat : Alkyd finishing paint.	1st coat : Epoxy red lead primer. 2nd coat : Epoxy red lead primer. 3rd coat : Epoxy finishing paint. 4th coat : Epoxy finishing paint.

Note: In case where there is a paint repair resulting from welding, cutting, drilling, polishing, or threading, zinc rich primer shall be used prior to the application of finishing paint.

(4) Colour Code

All pipes shall be colour coded except insulated pipes where only priming coats shall be applied to the pipe surface.

(a) In the electrical system, colour coding shall be only at the conduit clamps and the cover of junction boxes.

(b) Location of symbols and arrows indicating directions are as follows :

(i) Every 6 metres (20 ft.) internal of straight line pipe.

(ii) Near all valves.

(iii) Every change of direction and/or separation.

(iv) Where pipes passing through walls or floors.

(v) Near service pipe.

(5) Colour Codes of Various Systems

The identifications previously mentioned shall have colour as follows :

Description Code	Letters Symbol	Colour Code	Colour Symbol
Fire Water Supply for Sprinkler System	FSP	White	Red
Fire Water Supply for Fire Hose Cabinet	FHC	White	Red
Main Fire Water Supply	F	White	Red
Drain Pipe for Sprinkler System	DSP	White	Red
Conduit & Tray for Electrical Fire	FP	Orange	Red
Pipe Support & Hanger	-	Dark	Gray
Distribution Board & Motor Control Board Normal Electrical	-	Ivory	Black
Distribution Board & Motor Control Board Emergency Electrical	-	Ivory	Red

Final selection of colours will be made by the Engineer's Representative. All uninsulated pipes painted all over the pipe surface conforming to this colour codes.

4.12 TEST AND STERILIZATIONS

4.12.1 General

4.12.1.1 General Requirement

(1) All piping shall be tested by the Private Party and approved by the Engineer's Representative before acceptance.

(2) All equipment, materials, labour, etc. required for testing the fire protection system or the part thereof shall be furnished by the Private Party at no additional cost.

(3) All new, altered, extended or replaced plumbing shall be left uncovered and unconcealed until it has been tested and approved.

(4) Where such work has been covered or concealed before it is tested and approved, it shall be exposed for testing.

(5) Underground plumbing shall be tested and approved before back filling.

4.12.1.2 Standard and Reference

Test and sterilizations shall comply with the following codes and standards.

(1) National Fire Protection Association (NFPA)

NFPA 13/2002	:	Standard for the Installation of Sprinkler Systems
NFPA 14/2002	:	Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems
NFPA 20/2002	:	Standard for the Installation of Centrifugal Fire Pumps
NFPA 24/2002	:	Standard for the Installation of Private Fire Service Mains and Their Appurtenances

4.12.2 Material (Not used)

4.12.3 Execution

4.12.3.1 Field Testing

(1) Test all electrical equipment upon completion of installation to ensure that the equipment operates satisfactorily and to conform to contract documents.

(2) Field testing shall be required for all cables and electrical equipment furnished, installed or connected by the Private Party to assure proper installation, setting, connection, and functioning in accordance with the plans and specifications and manufacturer's recommendations.

(3) Testing shall be conducted in the presence of the Engineer’s Representative and, when necessary, under the supervision of equipment manufacturer's field engineer.

(4) All tests recommended by the equipment manufacturer whether specified in these Specifications or not, shall be included, unless specifically waived by the Engineer’s Representative.

(5) Testing shall include any additional tests issued by the Engineer’s Representative conditions to determine that equipment, material and system meet requirements of these Specifications.

(6) The Private Party shall maintain in quadruplicate a written record of all tests showing date, personnel making test, equipment or material tested, tests

performed and results. Two copies of test records shall be given to the Engineer's Representative.

(7) The Private Party shall notify the Engineer's Representative two weeks prior to commencement of any testing, except for meggering.

(8) Private Party shall be responsible for any damage to equipment or material due to improper test procedures or test apparatus handling, and shall replace or restore to original condition any damaged equipment or material.

(9) Safety devices such as rubber gloves and blankets, protective screens and barriers, danger signs, etc. shall be provided by the Private Party and shall be used to adequately protect and warn all personnel in the vicinity of the tests.

(10) The Private Party shall furnish all testing equipment, and furnish temporary power source of proper type for testing purposes when normal supply is not available at the time of testing.

(11) The conduit and wiring system, shall be checked to ensure that the system has been installed in such a way as to provide a safe and reliable system.

(12) The lighting system shall be checked at night to ensure that illumination levels as specified have been met.

(13) All interlocks, control and alarm circuits shall be given an operation test.

(14) The insulation test of each conductor shall not be lower than the accepted level as required by Authority concerned.

(15) The grounding system test shall not be more than 5 ohms.

(16) Test all miscellaneous equipment furnished by equipment manufacturer as recommended by the manufacturer, circuit breaker, low voltage switchboard, motor, etc unless specifically waived by the Engineer's Representative.

(17) Include all additional tests issued by Engineer's Representative that he deems necessary because of field conditions, to determine that equipment and material and systems meet requirements of these specifications.

(18) Be responsible for all damage to equipment or material due to improper test procedures or test apparatus handling.

4.12.3.2 Flushing of Piping

(1) Underground mains and lead-in connections to system risers shall be completely flushed before connection is made to sprinkler piping.

(2) The flushing operation shall be continued for a sufficient time to ensure thorough cleaning.

(3) The minimum rate of flow shall be not less than one of the following:

(a) Hydraulically calculated water demand flow rate of the system, including any hose requirements.

(b) Flow necessary to provide a velocity of 3.1 m/sec (10 ft/sec).

(c) Maximum flow rate available to the system under fire conditions.

(4) Piping between the fire department connection and the check valve in the inlet pipe shall be flushed with a sufficient volume of water in order to remove any construction debris and trash accumulated in the piping prior to the completion of the system and prior to the installation of the fire department connection.

4.12.3.3 Hydrostatic Test

(1) All piping and attached appurtenances subjected to system working pressure shall be hydrostatically tested at 13.8 kg/cm2 (200 psi) or 3.5 kg/cm2 (50 psi) in excess of the system working pressure, whichever is greater, and shall maintain that pressure without loss for 2 hours.

(2) The hydrostatic test pressure shall be measured at the low elevation point of the individual system or zone being tested.

(3) The inside standpipe system piping shall show no leakage.

(4) Piping between the fire department connection and the check valve in the inlet pipe shall be tested hydrostatically in the same manner as the balance of the system.

(5) During the hydrostatic test, the pressure gauge at the top of each standpipe shall be observed and the pressure recorded.

4.12.3.4 Flow Tests

(1) Water flow tests shall be carried out in accordance with NFPA 13 and NFPA 14 to verify the following :

(a) Mains water supply.

(b) All waterflow alarm devices.

(c) Flow rate at the hydraulically most remote sprinkler.

(d) Flow rate at the hydraulically most remote hosereel.

(2) The arrangement of piping work and fittings to facilitate these tests shall be as illustrated in NFPA 13 and NFPA 14, with safety shut-off valves and quick-action couplings for connection of the portable meter set.

4.12.3.5 Equipment Tests

In addition to the tests required by NFPA 20, the Private Party shall carry out functional tests on all flow switches, monitoring points and interface connections with the fire alarm and SCADA systems.

Packaged pump units shall be tested at the manufacturers works, and a detailed test certificate shall be provided.

4.12.3.6 System Operational Tests

(1) Waterflow detecting devices including the associated alarm circuits shall be flow tested through the inspector's test connection to result in an alarm on the premises within 5 minutes after such flow begins.

(2) The main drain valve shall be opened and remain open until the system pressure stabilizes. The static and residual pressures shall be recorded on the Private Party's test certificate.

(3) Operating tests shall be made of exposure protection systems upon completion of the installation, where such tests do not risk water damage to the building on which they are installed or to adjacent buildings.

4.12.3.7 Defective Work

(1) If the inspection or test shows defects, such defective work or material shall be replaced or repaired as necessary. Then inspection and tests shall be repeated.

(2) Repairs of piping shall be made with new materials. No caulking of screwed joints or holes will be acceptable.

4.12.3.8 Cleaning and Adjusting

Equipment, pipes, valves, fittings, and fixtures shall be clean without grease, metal cuttings, or sludge that may have accumulated from operation of the system during the test. Any stoppage, discolouration, or other damage to the finish, furnishings, or parts of the building, due to the Private Party's failure of cleaning the piping system properly, shall be repaired by the Private Party. When the Works is completed, the hot water system shall be adjusted for uniform circulation. Flush valves and automatic control devices shall be adjusted for proper operation.

4.12.3.9 Works to completion

(1) The Private Party shall commission, clean down, and leave in full working order the works as specified.

(2) The Private Party shall operate the systems in such a manner to be able to and ready to operate at full load anytime within a period of 24 consecutive hours.

(3) As the installation proceeds the Private Party shall prepare record drawings of the Electrical Installation, 'as built drawing. It will be sufficient to modify these contract drawings showing any amendments to the services which have taken place and submit the marked-up prints to the Engineer’s Representative for approval.

(4) The Private Party shall deliver to the Engineer’s Representative on completion of the works, manufacturer's literature, specifications, technical information and record drawings for all equipment installed.

4.12.3.10 Reports

After installations are completed, all equipment shall be test run. Any adjustments that are needed shall be made to assure that all equipment will operate with the required performance. Test run reports with all necessary data such as pressure, temperature, flow rate, current, voltage, etc., shall be recorded.