

Civil SPECIFICATIONS INDEX

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SECTION 01050

FIELD ENGINEERING

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Administrative and procedural requirements for Field Engineering services, including, but not limited to land survey work and Civil Engineering Services.

1.02 QUALITY ASSURANCE

- A. Contractor shall engage a qualified land surveyor(s) to perform the required land surveying services.
- B. Contractor shall carry out a soil investigation. if any findings conflict with those assumed by the Designer, then foundations shall be adjusted accordingly.
- C. Contractor shall engage a professional Engineer(s) to perform the required engineering services including.
- D. The engaged surveying and/or engineering team shall be approved by the Engineer.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.01 EXAMINATION

- . Verify accuracy of layout information shown on the Drawings, in relation to the property survey and existing benchmarks before proceeding to layout the Work. Locate and protect existing benchmarks and control points. Preserve permanent reference points during construction.
 - 1. Do not change or relocate benchmarks or control points without prior written approval from the Engineer. Promptly report lost or destroyed reference points or requirements to relocate reference points because of necessary changes in grade, location or conflicting construction.
 - 2. Promptly replace lost or damaged project control points with prior approval of the Engineer. Replacement of project control points shall be based on original survey control points.
 - 3. Establish and maintain the required number of permanent benchmarks on the job site as directed by the Engineer. Benchmarks shall be located from and referenced to data established from survey control points. Record benchmark location, with horizontal and vertical data, on Project Record Documents.

E. Existing utilities and equipment

1. The existence and location of underground and other utilities and construction indicated in the Construction Documents as existing are not guaranteed. Before beginning site work, investigate and verify the existence and location of underground utilities and other construction and record this information on the relevant plan.
2. Prior to construction, verify the location and invert elevation at points of connection to sanitary sewer, storm sewer and water service piping.

3.02 PERFORMANCE

A. General

1. Working from lines and levels established by the property survey, establish benchmarks and reference markers to set lines and levels at each story of construction and elsewhere as needed to properly locate each element of the Project. Calculate and measure required dimensions within indicated or recognized tolerances. Drawings shall not be scaled to determine dimensions.

B. Surveyor's Log

1. Maintain a Surveyor's Log of control and other survey work. Surveyor's Log shall be made available for the Engineer reference.
2. Record deviations from required lines and levels, and advise the Engineer when deviations that exceed indicated or recognized tolerances are detected. Contractor shall record on Project Record Drawings deviations that are accepted and not corrected.

C. Site Works

1. Locate and lay out works, fill and topsoil placement, slopes and invert elevations by instrumentation and similar appropriate means.
2. Prior to Substantial Completion, prepare a final property survey showing significant features (real property) for the Project. Include on the survey a certification, signed by the Surveyor, to the effect that principal metes, bounds, lines and levels of Project are accurately positioned as shown on survey.

END OF SECTION

SECTION 5

REFERENCE STANDARDS

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. References and Standards that are referred to throughout the Contract Documents to establish the following:
 - 1. Quality of a product.
 - 2. Type of product and workmanship.
 - 3. Methods for testing and reporting on the pertinent characteristics.
- B. Where materials or workmanship are required by the Contract Documents to meet or exceed the specifically named code or standard, the Contractor shall be responsible to provide materials and workmanship which meet or exceed the specifically named code or standard.
- C. Contractor shall be responsible, when required by Contract Documents, to deliver to the Engineer and/or Construction Manager documentation to prove that materials or workmanship, or both, meet or exceed the requirements of the specifically named code or standard. Such proof shall be in the form of a certified report of tests conducted by an approved testing agency.
- D. Specific naming of the codes or standards occurs on the Drawings and through the Sections of Specifications.

1.03 INTERNATIONAL ELECTRICAL COMMISSION - IEC

- A. The standard issued by the International Electrical Commission - IEC for electric works shall be given preference over other similar standards except the standard issued by the Saudi Arabian Standards Organization -
- B. New IEC standards issued before or after the commencement of the Project shall be implemented by the contractor and shall replace the equivalent foreign standards.

1.04 QUALITY ASSURANCE

- A. In procuring items used in this Work, the Contractor shall be responsible to verify the requirements of the specifically named codes and standards and to verify that the items procured for use in this Work meet or exceed the specified requirements.
- B. The Construction Manager reserves the right to reject items incorporated into the Work which fail to meet the specified minimum requirements.
- C. Reference to recognized Codes and Standards shall be by the use of the abbreviations listed. Reference to Codes and Standards shall not be limited to

the institutes listed herein:

AA	Aluminum Association
AABC	Associated Air Balance Council
AAMA	American Architectural Manufacturer's Association
AASHTO	American Association of State Highway and Transportation Officials
AATC	American Association for Textile Chemists and Colonists
ACA	American Correction Institute
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AMCA	Air Moving and Conditioning Association
ANSI	American National Standards Institute
ARI	American Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWI	American Welding Institute
AWPB	American Wood Preservative Bureau
AWS	American Welding Society
AWWA	American Water Works Association, Inc.
BHMA	Builders Hardware Manufacturers Association
BSI	British Standards Institution
CCITT	International Telegraphic and Telephone Consultative Committee
CISPR	International Special Committee on Radio Interference
CRSI	Concrete Reinforcing Steel Institute
DIN-EN	Deutsches Institute fuer Normung e.v.
EIA	Electronics Industries Association

FCC	Federal Communication Commission
HCISS	Higher Commission for Industrial Safety & Security
IAPMO	International Association Of Plumbing And Mechanical Officials
ICBO	International Conference of Building Officials
ICEE	International Commission Electrical Equipment
IEC	International Electrical Commission
IEEE	Institute of Electrical and Electronic Engineers
ISO	International Standards Organization
MSS	Manufacturers Standardization Society of the Valve and Fittings Industry
NAAMM	National Association of Architectural Metal Manufacturers
NEBB	National Environmental Balancing Bureau
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NSF	National Sanitation Foundation
NTMA	National Terrazzo and Mosaic Association
NWMA	National Woodwork Manufacturers Association
PCA	Portland Cement Association
PCI	Prestressed Concrete Institute
PDI	Plumbing and Drainage Institute
REA	Rural Electrification Administration
SMACNA	Sheet Metal and Air Conditioning Contractor's National Association
SSD	Saudi Security Directives
SSPC	Steel Structures Painting Council
UBC	Uniform Building Code
UL	Underwriters' Laboratories, Inc.
UMC	Uniform Mechanical Code

UPC Uniform Plumbing Code

VDE Verband Deutscher Elektrotechniker e.V.

Research Council on Riveted and Bolted Structural Joints of the
Engineering Foundation

References listed herein shall be deemed to include the latest edition or issue of such standards.

- D. Whenever there is conflict between the Drawings and/or the Specifications and the Codes, the Contractor shall bring the conflict to the Construction Manager's attention. The Engineer and/or Construction Manager shall then decide which shall govern.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

(Not Used)

END OF SECTION

SECTION 01300

SUBMITTALS

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Administrative and procedural requirements for the preparation of Submittals required in the performance of Work, including construction schedules, submittal schedules, daily/monthly construction progress reports, shop drawings, product data and samples.

1.02 CONSTRUCTION SCHEDULE

- A. Prepare a fully developed and cost loaded, horizontal bar chart type contractor's construction schedule. Submit schedule within 21 days of the date established for - Commencement of Work. Provide a separate time bar for each significant construction activity. Provide a continuous vertical line to identify the first working day of each week. Coordinate Contractor's construction schedule with the schedule of values, list of subcontractors, submittal schedule, progress reports, payment requests and other schedules. Contractor's Construction Schedule shall be subject to approval of the Engineer.
- B. Upon the request of the Engineer, Contractor shall submit a CPM schedule for the Engineer review and approval.

1.03 PROCUREMENT SCHEDULE

- A. Prepare a fully developed horizontal bar chart type material arrival schedule. The procurement schedule shall identify the material's submittal, ordering and arrival dates. Coordinate the procurement schedule with construction activities, submittal schedule, payment requests and other schedules. Contractor's Procurement Schedule shall be subject to approval of the Engineer.

1.04 SUBMITTAL SCHEDULE

- A. After development and acceptance of the Contractor's construction schedule, Contractor shall prepare schedule of submittals. Submit schedule within 10 days of the date required for establishment of construction schedule.
- B. Prepare schedule in chronological order, include submittals required during the first 90 days of construction including the necessary information (schedule dates for first submittal, for resubmittal, for the Engineer final release or approval and submittal category). Submittal Schedule shall be subject to approval of the Engineer.

1.05 PROGRESS REPORTS

- A. Daily Construction Reports
 - 1. Contractor shall prepare Daily Construction Reports utilizing the form approved by the Engineer. The Daily Construction Report shall include;

date, duration of working hours, count of personnel at the site, machinery and equipment at the site, general weather conditions, work performed, deliveries of material and equipment; special events, visitors, and inspections. Daily Construction Report shall be submitted to the Engineer.

B. Monthly Work Progress Reports

1. At the end of each month or at such periods of time as may be requested by the Engineer, the Contractor shall submit a detailed Monthly Work Progress Report utilizing the format approved by the Engineer. Monthly Work Progress Reports shall be prepared in Arabic and English and shall include a minimum of 25 photographs. Monthly Work Progress Report shall be submitted to the Engineer as one original and 4 copies.

1.06 SHOP DRAWINGS

A. General

1. Shop Drawings shall be submitted as newly prepared information, drawn to accurate scale. Shop Drawings shall be highlighted, clouded, or otherwise marked to indicate deviations from the Contract Documents. Contractor shall not reproduce Contract Documents or copy standard information as the basis of Shop Drawings. Standard information prepared without specific reference to Project will not be considered as Shop Drawings. Shop Drawings shall be submitted to the Engineer utilizing the Transmittal Form approved by the Engineer.
2. Shop Drawings shall include fabrication and installation drawings, setting-out diagrams, equipment or material schedules, patterns, templates and similar drawings.
3. Shop Drawings shall include, but not limited to the following information:
 - Dimensions
 - Identification of products and materials included
 - Compliance with specified standards
 - Notation of coordination requirements
 - Notation of dimensions established by field measurement
 - Profiles and cross sections
 - Materials and finishes

B. Sheet Size

1. Except for templates, patterns and similar full-size drawings, shop drawings shall be submitted on sheets sized as agreed with the Engineer.

C. Initial Submittal

1. Submit 2 blue or black-line prints for the Engineer's review, the corrected one will be returned to the Contractor.

D. Final Submittal

1. Submit 3 blue or black-line prints and one reproducible; submit 5 prints where required for maintenance manuals. Two prints will be retained; the

remainder will be returned. Do not use shop drawings without an appropriate final stamp indicating action taken in connection with construction.

E. Coordination Drawings

1. Coordination Drawings shall be submitted as required to eliminate potential conflicts in use of space. Coordination Drawings shall indicate the relationship and integration of different construction elements and/or pieces of equipment that require careful coordination during fabrication or installation to fit in the space provided.

1.07 PRODUCT DATA

A. General

1. Collect Product Data into a single submittal for each element of construction or system. Product data shall include printed information such as manufacturer's installation instructions, catalog cuts, standard color charts, roughing-in diagrams and templates, standard wiring diagrams and performance curves, and operation and maintenance manuals. Where Product Data must be specifically prepared because standard printed data is not suitable for use, submit as Shop Drawings.
2. Each copy of Product Data shall be marked to indicate the applicable choices and options. Where printed Product Data includes information on several products, some of which are not required, mark copies to indicate the applicable information.

B. Alternative Products

1. Specified materials, or products are indicative of quality standard required. Materials and products, other than those which are specified, will be considered only if the Contractor identifies his proposed material or product substitutions at the time of tender. Differences, including variation in the cost and/or schedule improvements to affected work, between the Contractor's proposed substitution and that which is specified shall be provided. Details of quality and difference, item by item, shall be provided for each proposed substitute material or product.

C. Submittals

1. Submit 2 copies of each required submittal, and 4 copies where required for maintenance manuals. the Engineer shall retain one copy, and return the other copies marked with action taken and corrections or modifications required. Unless noncompliance with Contract Document provisions is observed, the submittal may serve as the final submittal.

1.08 SAMPLES

- A. Contractor shall submit samples, as specified or as otherwise directed by the Engineer for the review of kind, color, pattern and texture; for a final check of these characteristics and there compatibility with other elements; and for a

comparison of these characteristics between the final submittal and the actual component as delivered and installed.

- B. Full-size, fully fabricated samples shaped and finished as specified and physically identical with the material or product proposed, shall be submitted to the Engineer. Samples shall include partial sections of manufactured or fabricated components, cuts or containers of materials, color range sets, and swatches showing color, texture and pattern.
- C. Samples shall be mounted, displayed, or packaged in the manner specified or as to facilitate review of the qualities indicated.
- D. Refer to other Specification Sections for requirements for samples illustrating workmanship, fabrication, techniques, details of assembly, connections, operation and similar construction characteristics.

1.09 AS-BUILT DRAWINGS

- A. During work progress and prior to acceptance of work, Contractor shall submit As-Built Drawings for the Engineer review and approval.
- B. Approved As-Built Drawings shall be submitted including one set in reproducible sheets and 2 sets of printed copies.
- C. As-Built Drawings shall be properly signed, dated and numbered.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

(Not Used)

END OF SECTION

SECTION 01400

QUALITY CONTROL

PART 1 - GENERAL

1.01 CONTRACTOR QUALITY CONTROL PROGRAM

- A. Provide a comprehensive Quality Control Program to assure that engineering, construction, materials, equipment and workmanship under this Contract are in compliance with contract provisions, applicable laws, codes and standards, and sound engineering and construction practices, unless specifically instructed otherwise by the Engineer.
- B. Quality Control program shall include, but not limited to, the following:
 - 1. Provisions for review and certification by a responsible representative of engineering, design and technical submittals to the Engineer under the terms of the Contract.
 - 2. Coordination of the Independent Testing Laboratory activities.
- C. Prior to commencing work at Site, appoint Contractor Quality Control (CQC) Manager supplemented as necessary by additional quality control personnel, who shall be on site at all times during progress, with complete authority to take any action necessary to ensure compliance with contract. CQC Manager shall report directly to the Engineer. CQC Manager's responsibilities may be delegated to the full-time Site Manager.
- D. Employ an Independent Testing Laboratory acceptable to the Engineer for performing quality control testing (soils, concrete, precast concrete, steel structure, masonry, asphalt and welding). As a minimum, laboratory shall meet the Recommended Requirements for Independent Laboratory Qualifications, published by the American Council of Independent Laboratories, the basic requirements of ASTM E 329 - Standards of Recommended Practice and Testing Agencies for Concrete and Steel as used in Construction; and shall be authorized to operate in Saudi Arabia for on-site testing. Contractor (within 30 days of effective date of site hand over) shall submit name, address and qualifications of the proposed Independent Testing Laboratory along with evidence of authority to operate in Saudi Arabia and qualifications of key laboratory personnel who will be responsible for the services for the Engineer review and approval.

1.02 CONTRACTOR QUALITY CONTROL PLAN

- A. Provide 5 copies of the Quality Control Plan to the Engineer for approval within 30 calendar days after the effective date of Site Handover. Quality Control Plan shall detail the procedures, instructions, and reports to be used to assure compliance with quality provision of this Contract. Quality Plan shall also include CQC organization chart, names and qualifications of personnel in quality control organization.
- B. Prior to submittal of Quality Control Plan for acceptance, Contractor shall meet with the Engineer and discuss quality control requirements. Quality system including forms to be used for recording the quality control operations,

inspections, tests, approvals, certifications, administration of the system, the Engineer surveillance, and on site/off-site testing facilities shall be detailed during this meeting(s).

- C. Unless specifically authorized by the Engineer, on-site constructions or off-site fabrication shall not start until the acceptance of the Quality Control Plan. Work will commence only after acceptance of the plan, or at least acceptance of that portion of the plan applicable to the specific feature of work.

1.03 WEEKLY REPORTS

- A. CQC Manager shall submit weekly CQC reports to the Engineer identifying prime contractor and subcontractor(s) activities such as work accomplished, inspections and tests conducted, results of inspection and tests, nature of defects found, causes of rejection, and corrective actions taken together with the following certification:

'On behalf of Contractor, I certify that this report is complete and correct, and materials and equipment used, and work performed during this reporting period are in compliance with Drawings and Specifications to the best of my knowledge, except as noted above.'

This certification shall be signed for the Contractor, and by authorized CQC Manager.

1.04 WORK DEFICIENCIES AND CORRECTION

- A. Contractor shall not build upon or conceal any work containing uncorrected defects. If deficiencies show that CQC Program is not adequate or does not produce desired results, corrective actions in both Contractor Quality Control Program and Work will be taken by Contractor. the Engineer may direct that changes be made in Contractor Quality Control Program or organization, including but not limited to, removal of unsatisfactory quality control representatives at any level.

1.05 CERTIFIED TEST REPORTS AND MANUFACTURER'S CERTIFICATES

- A. Before delivery of materials and equipment, submit and approve by the Engineer certified copies of reports of tests as required by Technical Specifications Sections, Applicable Codes, and Standards on good engineering practice.
- B. Unless the specific items provided were tested, test reports shall be accompanied by manufacturer certificates certifying that material and equipment proposed to be supplied is of the same type, quality, manufacturer, and as that tested.
- C. Certifications shall be original, naming appropriate item of equipment or material, specification, standard, or other document specified as controlling quality of that item and shall have attached thereto certified copies of test data upon which certifications are based. Certificates shall be signed by manufacturer's official authorized to sign certificates of conformance or compliance.

1.06 AUDIT

- A. Contractor Quality Control Plan implementation shall be subject to audit by the Engineer.

1.07 DUTIES OF INDEPENDENT TEST LABORATORY

- A. Provide adequate and acceptable plant and calibrated equipment to perform the required testing service.
- B. Develop qualified procedures for all required tests.
- C. Perform specified sampling and testing of materials and methods of construction.
 - 1. Comply with specified sampling and testing standards.
 - 2. Ascertain compliance of materials with requirements of Contract Documents.
- D. Promptly notify CQC of observed irregularities or deficiencies of work or products.
- E. Maintain accurate and complete records of all tests performed and promptly submit the original and one copy of the certified test report to the Contractor, one copy to the Engineer and one copy to Owner. Test report shall include the following as a minimum:
 - Date issued
 - Project title and number
 - Testing laboratory name, address and telephone number
 - Name and signature of laboratory inspector
 - Date and time of sampling or inspection
 - Record of temperature and weather conditions
 - Date of test
 - Identification of product and specification section
 - Location of sample or test in the Project
 - Type of inspection or test
 - Results of test and all test data in compliance with Contract Documents
 - Interpretation of test results, when requested by Owner
- F. Provide access to facilities and records to the Engineer and/or Owner and at reasonable times for the purpose of verifying qualifications of personnel, suitability of equipment, adequacy of methods, analysis of results and reporting methods.
- G. Prior to final payment, provide a tabulation of tests performed in connection with the Construction Contract, including conforming, non-conforming, and repeated test results. Tabulation(s) shall be certified as complete, and signed by

authorized representative of laboratory, and a copy shall be delivered to the Engineer.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

(Not Used)

END OF SECTION

SECTION 01500

TEMPORARY FACILITIES

PART 1 - GENERAL

0.01 SECTION INCLUDES

- A. Contractor shall provide, erect, install, maintain, alter as necessary, and remove on completion or when directed by the Engineer, temporary facilities and as described in Project Documents and/or specified in this section.

0.02 TEMPORARY ROADS

- A. Contractor shall prepare and maintain such temporary roads as may be necessary from the site to the nearest road and also within plot. Roads shall be positioned strictly in accordance with the Engineer instructions and the Contractor shall reduce or control any dust nuisance by spraying with water.
- B. Contractor shall satisfy himself as to the location and nature of the proposed access routes to site and shall be responsible for preventing any damage whatsoever to adjacent property and vegetation and keeping the access road free from debris at all times.

0.03 TEMPORARY SERVICES

A. General

- 1. Contractor shall make his own provisions with prior approval of the Engineer, or he shall perform necessary works required in conjunction with Project Documents.
- 2. Contractor shall bear costs related to installation, connection and maintenance of all temporary services and consumption of water and electricity during the entire duration of Project.

B. Temporary Water

- 1. Contractor shall supply in sufficient quantity all necessary potable and other water for construction purposes for other trades at a point within a reasonable distance from buildings being constructed. Contractor shall make arrangements and pay charges for water service installation, maintenance, and removal thereof, and pay cost of water for other trades.
- 2. When permanent water supply and distribution system has been installed, it may be used as the source of water for construction purposes, provided that the Contractor obtains the written approval of the Engineer, and assumes full responsibility for the entire water distribution system, and pays all cost of operation and maintenance of the system.
- 3. Temporary pipe lines and connections from the permanent service line, whether outside or within the building, but necessary for the use of the Contractor and his subcontractors, shall be installed, protected and maintained at the expense of the Contractor.

4. At completion of the work or at such time as the Contractor makes use of the permanent water supply installation, the temporary water service equipment and piping shall be removed by Contractor at his own expense.

C. Temporary Electricity

1. Contractor shall make all necessary arrangements for a temporary electrical service, pay all expenses in connection with the installation, operation and removal thereof, and pay the costs of electricity consumed by all trades.
2. In event that site cannot be connected to a local electricity network or where the available power is insufficient, Contractor shall make his own temporary provision and maintain such temporary installation until permanent supply is available and pay for expenses related in connection with such process.
3. A temporary lighting system shall be furnished, installed and maintained by the Contractor as required to satisfy the minimum requirements for safety and security. Temporary lighting system shall afford adequate general illumination to all building areas. Adequate outdoor lighting shall be provided to illuminate staging, trenches and the like to the satisfaction of the Engineer, and general illumination throughout adequate for watchmen and emergency personnel.
4. Temporary equipment and wiring for power and lighting shall be in accordance with the applicable provisions of governing codes. Temporary wiring shall be maintained in a safe manner and utilized so as not to constitute a hazard to persons or property.
5. When the permanent electrical power/lighting systems are in an operating condition, they may be used for temporary power and lighting for construction purposes, provided that Contractor obtains written approval of the Engineer and shall assume full responsibility for the entire power and lighting systems, and pays for operation and maintenance of the systems.
6. At completion of construction work, or at such time as the Contractor makes use of permanent electrical equipment and devices, temporary electricity services shall be removed by the Contractor at his own expense.

D. Waste Disposal

1. Contractor shall make such temporary provisions as may be required in order to dispose of any chemicals, fuels, oils, greases, bituminous materials, waste and soil waste and the like without causing pollution to either the site or the environment.
2. Disposal of any materials, wastes, effluent, garbage, oil, grease, chemicals and the like shall be in areas specified by the concerned local authority or municipality proposed by Contractor and subject to approval of the Engineer.
3. If any waste material is dumped in unauthorized areas, Contractor shall remove material and restore areas to condition of adjacent undisturbed

area. If necessary, contaminated ground shall be excavated, disposed of as directed by the Engineer, and replaced with suitable fill material, compacted, and finished with topsoil at the expense of the Contractor.

E. Fire Protection

1. Contractor shall provide and maintain adequate fire protection in the form of barrels of water with buckets, fire bucket tanks, fire extinguishers, or other effective means of extinguishing fire, ready for instant use, distributed around the project and in and about temporary inflammable structures during construction of the works. Gasoline and other flammable liquids shall be stored in and dispensed from safety containers approved by the Engineer and storage shall not be within buildings. Torch-cutting and welding operations performed by Contractor shall have the approval of the Engineer before such work is started and a chemical extinguisher is to be available at location where such work is in progress. Contractor shall follow instructions and specifications of the Civil Defense Department.

F. Telephone and Fax

1. Contractor shall immediately after receiving the Letter of Acceptance, install telephone system as mentioned in Clause 1.04 below including fax line for the Engineer. In case of nonavailability of telephone lines through STC, the Contractor shall provide one mobile telephone for exclusive use of the Engineer.
2. Contractor shall be responsible for payment of installation charges and periodic billing for all telephone and fax lines during construction period and up to substantial handover.

1.04 TEMPORARY ACCOMMODATION AND FACILITIES

- A. General: The location, construction, operation, maintenance and removal of the site offices, storage facilities and of any other temporary buildings of all persons or parties within perimeter of site, operating or associated as subcontractors to the Contractor shall be subject to the approval of Engineer. Contractor shall submit to the Engineer, prior to commencement of any temporary installations, plans showing the proposed position of site offices, storage, and buildings of a temporary nature.
- B. Habitable rooms shall be properly insulated, having dust-sealed windows with sun protection and insect screens, and shall be equipped with electric lights, air conditioning and/or mechanical ventilation, supporting facilities, hot and cold water, sewer and electrical facilities, and maintenance as required and to the satisfaction of Engineer.
- C. Engineering Site Office
 1. Contractor shall provide and maintain for entire duration of the project such administrative and supporting facilities as required for the sole use of Engineer and his staff. Building/s may be pre-fabricated or conventionally constructed and all rooms shall be sufficiently dimensioned to include essential furnishings. Temporary offices shall be available for use not later than one month after the date of the site handing over.
 2. The Engineering site office shall consist of at least the following :

- 5 Offices: Minimum 12 m² floor area each
- 1 Conference Room: Minimum 20 m² floor area
- 1 Reception Area: Minimum 9 m² floor area
- 1 sample Room: Minimum 12 m² floor area
- 1 Storage: Minimum 9 m² floor area
- 1 Kitchen 6 m² floor area
- 4 Toilets/washroom to serve 20 persons

Rooms shall have minimum 2.45m head. Construction shall be as approved by the Engineer prior to erection. The Contractor shall provide water, electricity, AC, telephone, drainage system and all such supplies shall be continuously furnished throughout construction period. Contractor shall be responsible to provide adequate and sufficient services for Engineer and his representatives including the messenger/office boy acceptable to Engineer in full time basis and shall keep the building in clean conditions. Contractor shall supply to the satisfaction of the Engineer the necessary office equipment and furniture including telephone sets, fax machine, electrical typewriter English and Arabic, desk calculators, advanced photocopy machine, chairs, desks, tables, filing cabinets and other items as required.

3. Communication Facilities: Contractor shall provide each room with telephone connection box. Telephone system shall be provided with a small PABX system, with two outside lines and 10 extension and the required number of telephone sets and a fax machine. Installation shall be maintained in good order.
4. Contractor shall furnish all offices to the satisfaction of the Engineer, and supply offices with office supplies of adequate quantities as directed by Engineer during entire project duration.
5. Contractor shall provide computer network complete with a server, 6 PC's (minimum), laserjet printer, A-4 size scanner and other required hardware and cabling. Latest Microsoft Windows based software shall be provided including AutoCAD, MS Office, MS Project and any other software required for the project.

D. Contractor's Facilities

1. Contractor shall, for his own use, furnish and maintain suitable offices, stores and auxiliary facilities on site. Contractor's office shall have computer network similar to Engineer's office, along with telephone services. He shall include for general use the following:
 - a. Sanitary Facilities: Toilets shall be provided and maintained on site or as directed by Engineer. Toilets shall be individually partitioned and the enclosures provided with lockable doors.
 - b. First Aid Facilities: Contractor shall provide adequate first aid facilities for joint use of his staff and Engineer and his personnel. They shall be made available at no extra cost.
 - c. Vehicle Parking: Contractor shall provide car park shade structure for 10 Engineer/Owner's cars and 2 spaces for visitors cars.

Parking shade structure shall be subject to approval of Engineer.

- d. Sample Room: The Contractor shall provide as directed by Engineer and near his office a sample room with appropriate shelving for the storage of complete set of approved samples of project. Contractor shall make the necessary modifications to the room as directed by the Engineer.

E. Labor Camps

- 1. A labor camp is not permitted on site.
- 2. Any labor camp or accommodation shall be provided for laborers off site and is expected to be fully in accordance with the laws of the Kingdom; and the Contractor shall be fully accountable and responsible for ensuring all labor laws are complied with, and security and conduct of such men are lawful.

F. Temporary Signboards:

- 1. Contractor shall provide, erect and maintain on suitable supports at entrances to site and as directed by Engineer, 2 signboards of minimum size 6 x 3.5 m constructed to the Engineer's design and consisting of softwood framing covered using marine quality plywood, primed and painted.
- 2. Provide signboards with the necessary lighting. Signboard shall be lettered in Arabic and English, giving name of Employer, name of Designer, Engineer, Contractor and Sub-Contractors. Setting out of signboards, type and sizes of lettering shall be approved by Engineer. Contractor shall clear away signboards upon completion of Contract or when requested to do so by Engineer.

1.05 TEMPORARY FENCE

- A. Contractor shall provide, install, maintain and remove a temporary fence around site. Construct fence using hollow steel tubes conforming to ASTM A 36 and corrugated galvanized sheet steel conforming to SDI Specifications. Sheet material shall be structural quality, 22 gage thick conforming to of ASTM A 446, Grade C, hot-dipped galvanized as per ASTM A 525, Class G-90. Size and shape of fence shall be as approved by Engineer.
- Excavation shall be in compliance with the requirements of Sections 02200 - EARTHWORK.
- Concrete shall be in compliance with the requirements of Section 03300 - CAST-IN-PLACE CONCRETE

0.06 TEMPORARY HOISTS AND CHUTES

- A. Contractor shall provide, install, maintain and remove material and personnel hoists as required for normal use by all trades, and employ only skilled operators for them. He shall provide necessary guards, signals, protective facilities, safety devices and the like required for safe operation, provide suitable runways from hoists to each floor level and roof, and remove all such facilities after they have

served their purpose or when directed by the Engineer.

- B. Contractor shall also provide and maintain all temporary ladders, ramps, runways, chutes, derricks, stairs, and similar items required for the proper execution of the work and permit the use of such facilities by other contractors, subcontractors or trades. Hoists and chutes shall be so constructed as to prevent damage, staining or marring of permanent work.
- C. No materials, rubbish or debris shall be permitted to drop free, but shall be removed by use of material hoist and/or fully enclosed rubbish chute.
- D. Where required, openings in slabs, walls and partitions shall be provided for installing large pieces of equipment. Openings shall be closed and/or made good after the equipment is in place. Structural modification, if required, shall be subject to prior approval by the Engineer.

0.07 STAGING AND SCAFFOLDING

- A. Contractor shall provide, erect and maintain all staging and scaffolding (exterior and interior) for all trades for their use during the construction of the building. Staging and scaffolding shall be of approved design, erected and removed by experienced stage builders and shall have all accident prevention devices required by government laws.
- B. Such staging and scaffolding shall be erected in sufficient time and in a proper sequence so as not to delay the works. Subcontractors shall schedule and commence their work so that building progress is not delayed or obstructed once staging and scaffolding becomes available.
- C. The above facilities shall be constructed and maintained in accordance with the applicable requirements of Government Authorities and designed to comply with the recommendations of the British Standards CP 97, Parts 1, 2 and 3, as applicable, and be removed after they have served their purpose or when directed by the Owner Representative.

0.08 TEMPORARY COVERINGS

- A. Contractor shall protect finished surfaces, including jambs and soffits of openings used as passageways or through which materials are handled, against possible damage resulting from the conduct of work by trades.
- B. Adequate protective material shall be laid under all materials stored on finished surfaces, and shall be laid before moving materials over finished areas. Wheelbarrows used over such areas shall have rubber type wheels.
- C. Finished surfaces, including factory-finished and job-finished items shall be clean and not marked upon handing over of building(s) to Owner. Contractor shall, without extra compensation, re-finish such spaces where surfaces were proved to have been inadequately protected, and which are damaged.
- D. As soon as an area of flooring is finished, it shall be protected by the Contractor from dirt and damage by covering as necessary with paper or by other approved method.
- E. Waterproofed and roof surfaces shall not be subjected to traffic, nor be used for

storage of material. Where some activity must take place in order to carry out the work, adequate protection, subject to approval by the Engineer shall be provided.

0.09 TEMPORARY SAFETY MEASURES

- A. Contractor shall provide and maintain during the entire contract period all temporary safety measures necessary for the protection of people, buildings, structures, paving, lighting, channels, fences and the like on the site or adjacent properties, and he shall be solely responsible for any damage to life and property caused as a result of not having taken adequate precautions against such damage.

PART 2 - PRODUCTS

0.04 MATERIALS

- B. General: Materials shall be new, and approved by the Engineer, and must not violate requirements of applicable codes and standards.

PART 3 - EXECUTION

0.05 GENERAL

- C. Maintain systems to assure continuous service.
- D. Modify and extend systems as work progress requires.

0.06 REMOVAL

- A. Completely remove temporary materials and equipment when their use is no longer required.
- B. Clean and repair damage caused by temporary installations or use of temporary facilities.
- C. Restore permanent facilities used for temporary services to specified conditions.

END OF SECTION

SECTION 01600

MATERIALS AND EQUIPMENT

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Products.
- B. Transportation and handling.
- C. Storage and protection.
- D. Product options.
- E. Substitutions.

1.02 PRODUCTS

- A. Products
 - 1. Means new material, machinery, components, equipment, fixtures, and systems forming Work. Products does not include machinery and equipment used for preparation, fabrication, conveying and erection of the Work. Products may also include existing materials or components required for re-use.
- B. Local Products
 - 1. Priority shall be given to products manufactured in the Kingdom of Saudi Arabia as long as they meet the reference standards and in conformance with the Project Documents requirements.
- C. Where applicable, use of materials and equipment removed from existing premises shall not be permitted, unless otherwise indicated on Contract Documents.
- D. For similar components, provide interchangeable components of same manufacturer.
- E. Product List Schedule
 - 1. Prepare a schedule showing products specified in a tabular form acceptable to the Engineer. Product List Schedule shall include generic names of products required, manufacturer's name and proprietary product names for each item listed. Coordinate product list schedule with Construction Schedule and Schedule of Submittals.
- F. Product Selection
 - 1. Provide products complying with Contract Documents specific performances indicated or specified, and which are recommended by manufacturer in writing for the intended application.

2. Materials and equipment to be used in Work shall be best quality, standard products of manufacturers and shall not show sign of defects or impurities. Where available, provide standard products of types that have been produced and used successfully in similar installations on other projects.
3. When matching of an established sample is required, the Engineer shall be the final judge of whether proposed product by Contractor matches the sample satisfactorily.
4. References made in the Specifications to approved manufacturers shall be construed as establishing a standard of quality and not as a limitation to the competition.

1.03 TRANSPORTATION AND HANDLING

- A. Transport and handle products in accordance with manufacturer's instructions.
- B. Inspect shipments to assure that products comply with the requirements, undamaged and are correct in quantities.
- C. Provide equipment and personnel as necessary to handle products by methods to prevent soiling, disfigurement, or damage.

1.04 STORAGE AND PROTECTION

- A. Provide secure storage for products, and protect stored products from pilferage, vandalism, and other loss or damage. Store and secure products so as not to present a safety hazard.
- B. Store and protect products in accordance with manufacturer's instructions, with seals and labels intact and legible. Store sensitive products in weather-tight, climate controlled enclosures.
- C. For exterior storage, fabricated products shall be placed on sloped supports, located above ground.
- D. Provide off-site storage and protection when site does not permit on-site storage or protection.
- E. Products subject to deterioration shall be covered with impervious sheet covering. Ventilation of covered products shall be provided to avoid condensation damage.
- F. Loose granular materials shall be stored on solid flat surfaces in a well-drained area. Precautions shall be taken to prevent mixing with foreign matter.
- G. Provide equipment and personnel to store products by methods to prevent soiling, disfigurement, or damage.
- H. Store products organized in such a way as to permit access for inspection. Contractor shall periodically inspect stored products to assure that they are undamaged and are being maintained under specified conditions.

1.05 PRODUCT OPTIONS

- A. Reference in Specifications to approved manufacturers shall be construed as establishing a standard for minimum quality and not as limiting of competition.
- B. Products of equal in quality to or better than those specified, shall be considered acceptable or approved. Acceptability and/or approval shall be decided and/or approved by the Engineer.
 - 1. Products Specified by Reference Standards or by Description Only: Any product meeting those standards or description may be furnished.
 - 2. Products Specified by Naming One or More Manufacturers: Products of named manufacturers and meeting specified requirements shall be furnished; no options or substitutions shall be allowed.
 - 3. Products Specified by Naming One or More Manufacturers with a Provision for Substitutions (i.e. or approved equal): Submit a request for substitution for any manufacturer not named complying with the requirements detailed in this specifications.

1.06 SUBSTITUTIONS

- A. Requests for Substitutions shall be in accordance with the General Conditions and Section 01300 - SUBMITTALS of this Specification.
- B. The consideration of Contractor requests for Substitutions shall be subject to the Engineer review and approval. The Owner shall have final approval authority over requests for Substitutions.
- C. Substitutions may be considered when a product becomes unavailable through no fault of the Contractor.
- D. Contractor shall document each request with complete data substantiating compliance of proposed Substitution with Contract Documents.
- E. A request for product substitution constitutes a representation that the Contractor:
 - 1. Has investigated proposed product and determined that it meets or exceeds quality level of specified product.
 - 2. Will provide same warranty for Substitution as for specified product.
 - 3. Will coordinate installation of Substitution and make changes to other Work which may be required for Work to be complete at no additional cost to Owner.
 - 4. Waives claims for additional costs or time extension which may subsequently become apparent.
- F. Substitutions will not be considered when they are indicated or implied on shop drawing or product data submittals, without separate written request, or when acceptance will require revision to the Contract Documents.

G. Substitution Submittal Procedure

1. Submit 4 copies of request for Substitution for consideration. Limit each request to one proposed Substitution.
2. Submit shop drawings, product data, and certified test results attesting to the proposed product equivalence.
3. The Engineer will notify Contractor, within 2 weeks of receipt of a substitution request and in writing, of his decision to accept or reject such a request.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

(Not Used)

END OF SECTION

SECTION 01700

PROJECT CLOSE-OUT REQUIREMENTS

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Project Closeout: Term used to describe certain collective project requirements, indicating completion of Work that are to be fulfilled near end of Contract time in preparation for final acceptance and occupancy of Work by Owner, as well as final payment to the Contractor and normal termination of Contract.
- B. Time of Closeout: Directly related to "Substantial Completion"; therefore, the time of closeout may be a single time for individual elements of the work that have been certified as substantially complete at different dates. This time variation, if any, shall be applicable to the other provisions of this Section.

1.02 PREREQUISITES TO SUBSTANTIAL COMPLETION

- A. General: Complete the following before requesting the Handover Committee inspection for certification of substantial completion, either for the entire work or for portions of the Work.
 - 1. In progress payment request that coincides with, or is the first request following date of substantial completion is claimed, show either 100% completion for portion of work claimed as "substantially complete", or list incomplete items, the value of incomplete work, and reasons for Work being incomplete.
 - 2. Include supporting documentation for completion as indicated in these contract documents.
- B. Submit a statement showing an accounting of changes to the Contract Sum.
- C. Submit specific warranties, workmanship/maintenance bonds, maintenance agreements, final certifications and similar documents.
- D. Obtain and submit releases enabling the Owner's full, unrestricted use of the Work and access to services and utilities. Where required, include occupancy permits, operating certificates and similar releases.
- E. Submit record drawings, maintenance manuals, final project photographs, damage or settlement survey, property survey, and similar final record information.
- F. Deliver tools, spare parts, extra stock of materials and similar physical items to the Owner.
- G. Make final change-over of locks and transmit keys to Owner. Advise Owner's personnel of change-over in security provisions.
- H. Complete start-up testing of systems, and instruction of the Owner's operating and maintenance personnel. Discontinue or change over and remove temporary

facilities and services from the project site, along with construction tools and facilities, mock-ups, and similar elements.

- I. Complete final cleaning-up requirements, including touch-up painting of marred surfaces.
- J. Touch-up and otherwise repair and restore marred exposed finishes.
- K. Inspection Procedures: Upon receipt of Contractor's request for inspection, Handover Committee will either proceed with inspection or advise Contractor of unfilled prerequisites.
 - 1. Following initial inspection, Handover Committee will either prepare Certificate of Substantial Completion, or will advise Contractor of work which must be performed before certificate will be issued. Handover Committee will repeat inspection when requested and when assured that work has been substantially completed.
 - 2. Results of the completed inspection will form the initial "Punch List" for final acceptance.

1.03 PREREQUISITES TO FINAL ACCEPTANCE

- A. General: Complete the following before requesting the Engineer final inspection for certification of final acceptance, and final payment as required by the General Conditions. List known exceptions, if any, in the request.
 - 1. Submit the final payment request with final releases and supporting documentation not previously submitted and accepted. Include certificates of insurance for products and completed operations where required.
 - 2. Submit an updated final statement, accounting for final additional changes to the Contract Sum.
 - 3. Submit a certified copy of the Engineer final Punch List of itemized work to be completed or corrected, stating that each item has been completed or otherwise resolved for acceptance and has been endorsed/dated by the Engineer.
 - 4. Submit final meter readings for utilities, a measured record of stored fuel, and similar data either as of the date of substantial completion, or else when the Owner took possession of and responsibility for corresponding elements of the work.
 - 5. Submit Certificate of Payment, Zakat and Income.
- B. Re-inspection Procedure: The Engineer shall re-inspect the Work upon receipt of the Contractor's notice that the Work, including Punch List items resulting from earlier inspections, has been completed, except for these items whose completion has been delayed because of circumstances that are acceptable to the Engineer.
 - 1. Upon completion of re-inspection, the Engineer will either prepare a certificate of completion of the Maintenance Period or will advise the Contractor of work that is incomplete or of obligations that have not been

fulfilled, but are required for final acceptance.

2. If necessary, the re-inspection procedure will be repeated.

1.04 RECORD DOCUMENT SUBMITTALS

- A. As-Built Drawings: Contractor shall prepare As-Built drawings from the shop drawings. Information shall be presented in the following form:
 1. Electronic Files: As-Built drawings files shall be submitted to the Engineer. Drawings shall be prepared using latest AutoCAD version (*.DWG Format).
 2. Reproducible Copies (Sepia): All As-Built drawings and other Contract documents.

Copies of the As-Built drawings shall be submitted in accordance with SECTION 01300 - SUBMITTALS for approval.

- B. Specifications: Complete mark-up of Technical Specifications shall be submitted to the Engineer before initial acceptance.
- C. Record Product Data: During the progress of the work maintain one copy of each product data submittal, and mark up significant variations as approved by the Engineer in the actual work in comparison with the submitted information.

Include both variations from the manufacturer's instructions and recommendations for installation. Give particular attention to concealed products and portions of the work which cannot otherwise be readily discerned at a later date by direct observation. Note related change orders and mark-up of record drawings and specifications. Upon completion of mark-up, submit complete set to the Engineer for record.

- D. Record Sample Submittal: Immediately prior to the time(s) of initial completion, the Engineer will meet with Contractor at site, and will determine which of the submitted samples maintained by the Contractor during the progress of the work are to be submitted to the Engineer for record purposes.
- E. Miscellaneous Record Submittals: Immediately prior to time(s) of initial completion, complete miscellaneous records and place in good order, properly identified and bound or filled, ready for continued use and reference. Submit to the Engineer for record.

1.05 OPERATING AND MAINTENANCE INSTRUCTIONS

- A. Arrange for each Installation of work requiring continuing maintenance or operation to meet with the operating personnel at the project site to provide basic instructions needed for proper operation and maintenance of the entire work. Review maintenance manuals, record documentation, tools, spare parts and materials, lubricants, fuels, identification system, control sequences, hazards, cleaning and similar procedures and facilities. For operation equipment, demonstrate start-up, shut-down, emergency operations, noise and vibration adjustments, safety, economy/ efficiency adjustments, and similar operations. Review maintenance and operations in relation with applicable guarantees, warranties, agreements to maintain, bonds, and similar continuing commitments.

- B. Contractor shall submit 2 sets of Operation and Maintenance data prior to final inspection, size A-4 and/or A-3 text pages as applicable, bound in expandable binders with durable covers.
- C. Contractor shall prepare binder covers with printed title - OPERATION AND MAINTENANCE INSTRUCTIONS, title of project, and subject matter of binder when multiple binders are required.
- D. Language for Operation and Maintenance Manuals: Manuals shall be prepared in Arabic and English. Where manufacturer's Arabic literature shall not be available, Contractor shall be responsible for providing the Arabic translated manuals.
- E. Binder contents shall be internally subdivided with permanent page dividers; logically organized as described below, with tab titling clearly printed under reinforced laminated plastic tabs.
- F. Binder Contents: Contractor shall prepare a Table of Contents for each volume, with each Product or system description identified.
- G. Binder - Part 1: Directory, listing names, addresses, and telephone numbers of Architect/Engineer, the Engineer, Contractor, subcontractors, and major equipment suppliers.
- H. Binder - Part 2: Operation instruction and maintenance manuals, arranged by system and subdivided by Specification section.

For each category, identify names, addresses, and telephone numbers of subcontractors and suppliers. Identify the following:

- 1. List of equipment.
 - 2. Significant design criteria including performance data, dimensions, weights, and capacities.
 - 3. Parts list for each component.
 - 4. Installation instructions.
 - 5. Operating instructions.
 - 6. Maintenance manuals and instructions for equipment and systems including service manuals and wiring diagrams.
 - 7. Maintenance instructions for finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.
- I. Binder - Part 3: Project documents and certificates, including the following:
 - 1. Shop drawings and product data.
 - 2. Air and water balance reports.

3. Potable water system disinfection reports.
 4. Elevator and dumbwaiter test reports and certifications.
 5. Other certificates as specified.
 6. Photocopies of warranties, guaranties, and bonds.
- J. Contractor shall submit one copy of the completed binder volumes in the final form 30 days prior to final inspection at substantial completion. This copy will be returned after final inspection, with the Engineer comments. Revise content of documents as required prior to final submittal.
- K. Within 10 days after final inspection, Contractor shall submit 2 copies of the final revised binder volumes to the Engineer for hand-over to Owner.

1.06 FINAL CLEANING

- A. Special cleaning for specific units of work is specified in the various technical specifications.
- B. Provide final cleaning of the work at the time indicated, consisting of cleaning each surface or unit of work to the normal "clean" condition expected for a first class building cleaning and maintenance program. Comply with manufacturer's instructions for cleaning operations.
- C. Except as otherwise indicated or requested by the Owner, remove temporary protective devices and facilities which were installed during the course of the work to protect previously completed work during the remainder of the construction period.
- D. Comply with the safety standards and governing regulations for cleaning operations. Do not burn waste materials at the site, nor bury debris or excess materials on the property, nor discharge volatile or other harmful or dangerous materials into drainage system. Remove waste materials from the site and dispose of in lawful manner.

1.07 WARRANTIES AND BONDS

- A. Submit written warranties to the Engineer prior to the date certified for Substantial Completion. If the Engineer certificate of Substantial Completion designates a commencement date for warranties other than the date of Substantial Completion for the Work, or a designated portion of the Work, submit written warranties upon request of the Engineer.

When a special warranty is required to be executed by the Contractor, or the Contractor and a subcontractor, supplier or manufacturer, prepare a written document that contains appropriate terms and identification, ready for execution by the required parties. Submit a draft to the Owner through the Engineer for approval prior to final execution.

Refer to individual sections of Division 2 through 16 each specific content requirements, and particular requirements for submittal of special warranties.

- B. Form warranties and bonds in heavy-duty, commercial quality, durable 3-ring

vinyl covered loose-leaf binders, thickness as necessary to accommodate contents, and sized to receive A-4 paper.

1.08 CONTINUING INSPECTIONS

- A. Where required by special guarantees, warranties, agreements to maintain, workmanship bonds and similar continuing commitments, comply with requests to participate in inspections at the end of each time period of such continuing commitments.

1.09 DELIVERY TURNOVER INVENTORY REQUIREMENTS

- A. Upon product delivery, the Contractor shall:
 - 1. Conduct tests and operational checks to ensure serviceability.
 - 2. Verify cleanliness and overall condition as acceptable.
 - 3. Ensure that manufacturer's operations and maintenance manuals are available for transfer.
 - 4. Ensure that keys to rolling stock, buildings and equipment are ready for turnover to the Owner.

PART 2 - PRODUCTS

(Not used)

PART 3 - EXECUTION

(Not Used)

END OF SECTION

SECTION 02060

DEMOLITION

PART 1 - GENERAL

0.01 SECTION INCLUDES

- A. Demolition, removal and disposal of foundations, underground structures, utilities and other items as indicated on drawings and specified in this section.

GENERAL REQUIREMENTS

- A. Work includes demolition of foundations, underground structures, utilities and other items as required as well as removal of resulting rubbish and debris.
- B. Remove rubbish and debris from site daily, unless otherwise directed, to avoid accumulation at demolition site.
- C. Store materials that cannot be removed daily in areas specified by the Engineer.
- D. Dispose materials off site as specified and as directed by the Engineer.

SUBMITTALS

- A. Detailed drawings of temporary works, if required, and detailed sequence of operations to ensure uninterrupted progress works on site.
- B. Work Plans for demolition work: Demolition and removal work shall not interfere with existing utilities, traffic on roads, nor shall it interfere with the continuity of access or use of adjoining areas, except as approved. When interference with existing utilities, traffic or continuity of use of any area is required, work plan shall be furnished to the Engineer for review and approval not less than twenty-five working days before starting work.
- C. When required, the necessary permits shall be completed by Contractor and submitted for review and approval by the Engineer. When approved, schedule Work to create the least interference and inconvenience to adjoining areas and public. At all times public safety shall be protected.
- D. No work shall proceed until the above submittals have been approved by the Engineer.

PART 2 - PRODUCTS

(Not Used)

1. PART 3 - EXECUTION

1.01 PROTECTION

- A. Before beginning any demolition work, survey site carefully and examine Drawings and Specifications to determine the extent of Work. Investigate the presence of foundations and other underground structures as well as utilities required to be demolished. Demolition and removal work shall be performed in a manner to prevent damage to the remaining and adjoining structures, facilities and utilities without jeopardizing their use or occupancy. Damage to adjoining structures, facilities and utilities shall be repaired as approved by the Engineer.
- B. Provide temporary barricades and other forms of protection to protect personnel and general public from injury due to demolition work as well as keeping non-authorized public traffic off site during the project duration.
- C. Protect from damage existing finish work that is to remain in place and become exposed during demolition operations. Protect floors with suitable coverings when necessary.
- D. Provide temporary weather protection when removal or demolition involves exterior walls, windows or doors.
- E. Remove protection at completion of work.

TRAFFIC

- A. Conduct demolition and debris removal to ensure minimum interference with adjacent occupied or used facilities.
- B. Do not close, block or otherwise obstruct areas or used facilities without a written authorization from Owner.
- C. Provide alternate routes around closed or obstructed traffic ways if required by the Engineer.

UTILITY SERVICES

- A. Maintain existing utilities indicated to remain in service and protect them against damage during demolition operations. Do not interrupt utilities serving occupied or used facilities, except when authorized in writing by Owner. Provide temporary services during interruptions to existing utilities, as acceptable to Owner. Maintain fire protection services during demolition operations.
- B. Locate, identify and disconnect utility services that are not indicated to remain and provide bypass connections to maintain continuity of services to occupied areas of building.

DEMOLITION

- A. Perform demolition work in a systematic manner.
- B. Use methods acceptable to the Engineer to complete the required demolition, and in accordance with approved demolition schedule and governing regulations.
- C. Items to be demolished shall include but not limited to following:
 - 1. Foundations
 - 2. Underground Structures, if any
 - 3. Underground Utilities, if any
 - 4. Any other items required to be demolished

DISPOSAL

- A. Concrete, masonry, and other noncombustible materials, except concrete permitted to remain in place, shall be disposed of in legal manner in the designated disposal areas, off site.
- B. Combustible materials shall also be disposed off site in a legal manner.
- C. Debris and rubbish shall be removed from site. Debris shall be removed and transported in a manner that prevents spillage on streets or adjacent areas. Local regulations regarding hauling and disposal shall apply.

DUST CONTROL

- A. Amount of dust resulting from demolition shall be controlled to prevent spread of dust to other portions of construction site and to avoid the creation of nuisance in the surrounding area(s). Use of water will not be permitted when it will result in, or create, hazardous or objectionable conditions such as flooding and pollution.

BURNING

- A. Use of burning at Project site for disposal of refuse and debris will not be permitted.

USE OF EXPLOSIVES

- A. Use of explosives will not be permitted.

CLEANUP AND REPAIR

- A. Upon completion of demolition work, remove tools, equipment, and demolished materials from site and leave site in a clean condition.

- B. Repair demolition performed in excess of that required. Return elements of construction and surfaces to remain to condition existing prior to start operations.

END OF SECTION

SECTION 02110

SITE CLEARING

PART 1 - GENERAL

0.01 SECTION INCLUDES

- A. Removal and disposal of vegetation, brush, rubbish, loose rocks, large stones and metallic debris occurring within the areas to be cleared as well as removal of roots, matted roots and organic materials to a depth of not less than 300 mm below original surface level of ground or to natural rock elevation.
- B. Removal and satisfactory disposal of any structure that obtrude, encroach upon, or otherwise obstruct the Work indicated on Drawings.

0.02 JOB CONDITIONS

- A. Traffic: Conduct site clearing operations to ensure minimum interference with roads, streets, walks and other adjacent occupied or used facilities. Do not use facilities without permission from the Engineer or authorities having jurisdiction.
- B. Protection of Existing Improvements (If required): Provide protection as necessary to prevent damage to existing improvements indicated to remain in place.
 - 1. Protect improvements on adjoining properties and on Owner's property.
 - 2. Restore damaged improvements to their original condition, as acceptable to parties having jurisdiction.

1. PART 2 - PRODUCTS

(Not Used)

2. PART 3 - EXECUTION

2.01 SITE CLEARING

- A. General: Remove trees, shrubs, grass and other vegetation, improvements or obstructions interfering with the execution of the new construction. Remove such items elsewhere on site or premises as specifically indicated. Removal includes digging out stumps and roots.
- B. Clearing and Grubbing: Remove material to be grubbed, together with logs and other organic or metallic debris not suitable for foundation

purposes to a depth of not less than 300 mm below the original surface level of the ground in areas indicated to be grubbed and in areas indicated as construction areas under this Contract, such as areas for buildings, and areas to be paved. Depressions made by grubbing shall be filled with suitable material and compacted to make the surface in conformance with the original adjacent surface of the ground.

- C. Removal of Improvements: Remove existing above-grade and below-grade improvements necessary to permit construction and other works as indicated on drawings.

2.02 DISPOSAL OF WASTE MATERIALS

- A. Transport waste materials and unsuitable topsoil materials to the designated spoil areas and dispose of as directed by the Engineer at no extra cost.
- B. Dust Control: Amount of dust resulting from demolition shall be controlled to prevent the spread of dust to occupied portions of the construction site and to avoid creation of a nuisance in the surrounding area. Use of water will not be permitted when it will result in, or create, hazardous or objectionable conditions.

2.03 BURNING

- A. Use of burning at the Project Site for the disposal of refuse and debris shall not be permitted.

2.04 USE OF EXPLOSIVES

- A. Use of explosives shall not be permitted.

END OF SECTION

SECTION 02510

ASPHALT CONCRETE PAVING

1. PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Providing asphalt concrete paving in one layer system or two layers system including placement and compaction as shown on Drawings and as specified in this section.

1.02 REFERENCES

- A. AASHTO - American Association of State Highway and Transportation Officials

AASHTO T 11 Material Finer than 0.075 mm (No. 200) Sieve in Aggregate

AASHTO T 27 Sieve Analysis of Fine and Coarse Aggregates

AASHTO T 44 Solubility Test for Bituminous Materials

AASHTO T 49 Penetration of Bituminous Materials

AASHTO T 51 Ductility of Bituminous Materials

AASHTO T 84 Specific Gravity and Absorption of Fine Aggregates

AASHTO T 85 Specific Gravity and Absorption of Coarse Aggregates

AASHTO T 96 Resistance to Abrasion of Coarse Aggregate by Use of the Los Angeles Machine

AASHTO T 104 Soundness of Aggregates by Use of Sodium Sulfate of magnesium Sulfate

AASHTO T 112 Friable Particles in Aggregates

AASHTO T 176 Sand Equivalent Test

AASHTO T 180 Proctor Compaction Tests

AASHTO T 182 Coating and Stripping Test

AASHTO T 191 Field Density Determination

AASHTO T 193 California Bearing Ratio test

B. ASTM - American Society for Testing and Materials

ASTM C 88	Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 117	Test Method for Material Finer than 0.075 mm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 127	Test Method for Specific Gravity and Absorption of Coarse Aggregates by Washing
ASTM C 131	Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C 535	Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM D 75	Practice for Aggregate Sampling
ASTM D 140	Practice for Bituminous Material Sampling
ASTM D 242	Specifications for Mineral Filler for Bituminous Paving Mixtures
ASTM D 448	Classification for Sizes of Aggregate for Road and Bridge Construction
ASTM D 946	Specifications for Penetration-Graded Asphalt Cement for Use in Pavement Construction
ASTM D 977	Specifications for Emulsified Asphalt
ASTM D 995	Requirements for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
ASTM D 1188	Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens
ASTM D 1556	Test Method for Density of Soil in Place by the Sand-Cone Method
ASTM D 1557	Test Method for Moisture-Density Relations of Soils, and Soil-Aggregate Mixtures using 10-lb (4.5-kg) Rammer and 18-inch (457-mm) Drop

ASTM D 1559	Test Method for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
ASTM D 1664	Test Method for Coating and Stripping of Bitumen-Aggregate Mixtures
ASTM D 1883	Test Method for CBR (California Bearing Ratio) of Laboratory-Compacted Soils
ASTM D 2027	Specifications for Cutback Asphalt (Medium-Curing Type)
ASTM D 2028	Specifications for Cutback Asphalt (Rapid-Curing Type)
ASTM D 2041	Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D 2172	Test Methods for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D 2419	Test Method for Sand Equivalent Value of Soil and Fine Aggregate
ASTM D 2726	Test Method for Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens
ASTM D 3515	Specifications for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
ASTM D 3549	Test Method for Thickness or Height of Bituminous Paving Mixture Specimens

C. CRD - U.S. Army, Corps of Engineers

CRD-C 119	Method of Testing for Flat and Elongated Particles in Coarse Aggregates
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D. AI - Asphalt Institute

AI-MS 2	Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types
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1.03 SUBMITTALS

- A. Samples: Materials and Bituminous Mixture.
- B. Certificate of Compliance for Materials.
- C. Test Reports.

- D. In addition to the above, submit the following:
 - 1. Job-Mix Formula.
 - 2. Schedule
 - 3. List of Plant and Equipment.
 - 4. Detail and procedures of furnishing and delivering asphalt cement from off-site plant.

1.04 QUALITY ASSURANCE

- A. Tests specified herein and additional tests as may be necessary to determine the quality of the work will be performed by the Contractor using an independent testing laboratory nominated by the Contractor and approved by the Engineer. Contractor shall restore areas where samples have been taken so that such areas will conform to these specifications.

2. PART 2 - PRODUCTS

2.01 MATERIALS

- A. Sub-Grade
 - 1. Conform to the requirements specified in Section 02200 - EARTHWORK.
- B. Granular Sub-Base
 - 1. Conform to the requirements specified in Section 02200 - EARTHWORK.
- C. Aggregates
 - 1. Aggregates shall consist of coarse aggregates and fine aggregates, and filler material, if required, all conforming to MOC Specifications and the requirements specified herein. Aggregates shall consist of crushed rock or crushed gravel, clean, hard, tough, durable, uniform quality, and free from organic material.
 - 2. Aggregates shall be obtained from an approved quarry and shall consist of a mixture of all aggregate uniformly graded from coarse to fine.
 - 3. Combined aggregates shall conform to the following gradation requirements when tested in accordance with AASHTO T 27 or ASTM C 117 and ASTM C 136:

Percent Passing by Weight

Sieve Size	Percent Passing by Weight	
	Base Course	Wearing Course
19.05 mm (3/4 in)	100	-
13.00 mm (1/2 in)	80-95	100
9.50 mm (3/8 in)	-	80-100
4.75 mm (No. 4)	48-62	55-75
2.00 mm (No. 10)	32-45	32-47
0.425 mm (No. 40)	16-26	16-26
0.25 mm (No. 80)	8-18	10-18
0.075 mm (No. 200)	4-8	4-10

Grading limits specified here are based on materials of uniform specific gravity and shall be adjusted by the Engineer to compensate for any variation in specific gravity of the individual sizes. The grading may be varied by the Engineer of Marshall Tests to obtain optimum stability and life of completed wearing course mix.

4. Processed aggregates shall consist of 100 percent crushed stone of hard durable particles having two or more broken faces, free from dirt and other objectionable matter, and meeting the following physical requirements when tested in accordance with ASTM C 117 and ASTM C 136:
 - a. Plasticity Index: 3 Percent maximum as per AASHTO T 90 or ASTM D 424
 - b. Sand Equivalent: 45 percent minimum as per AASHTO T 176
 - c. Loss of Sodium Sulfate (Soundness Test):
10 percent maximum as per AASHTO T 104 or ASTM C 88
 - d. Loss of Magnesium Sulfate (Soundness Test):
12 percent maximum as per AASHTO T 104 or ASTM C 88
 - e. Loss by Abrasion Test: 40 percent maximum as per AASHTO T 96 or ASTM C 131 or ASTM C 535
 - f. Flat and Elongated Particles: 5 percent maximum as per CRD-C119
 - g. Friable Particles: 0.25 percent maximum as per AASHTO T 112

- D. Asphalt Cement: Petroleum asphalt cement, Grade 60 - 70 penetration, conforming to AASHTO M 20 or ASTM D 946.
- E. Liquid Asphalt
 - 1. Prime Coat: Medium-curing cutback asphalt conforming to AASHTO M 82, Grade MC-1 or ASTM D 2027, Grade MC-70.
 - 2. Tack Coat: AASHTO T49, Grade RC-2 or ASTM D2028, Grade RC70.
- F. Mineral Filler: Rock or slag dust, hydraulic cement, or other inert material complying with AASHTO M 17 or ASTM D 242.

2.02 BITUMINOUS PLANT MIX

- A. Job Mix
 - 1. A satisfactory job-mix formula shall be established for each mixture used. Formula shall establish a single percentage of aggregate passing each sieve size, a single percentage of bituminous material to be added, and a single temperature at which the mixture is to be delivered at the point of discharge. Procedures shall conform to ASTM D 1559.
 - 2. Combined mineral aggregates and asphalt shall conform to the following composition limits by weight.
 - a. Total Mineral Aggregates (percent) : 92 - 96
 - b. Asphaltic Binder (percent) : 4 - 8
 - 3. When tested according to ASTM D 1559 (75 blows each face) the bituminous mixture shall conform to the following requirements. Bituminous mixture properties shall be determined in accordance with procedures contained in AI MS-2.
 - a. Stability (Marshall)
 - 1. Base Course : 500 Kg minimum
 - 2. Wearing Course : 700 Kg minimum
 - b. Flow (millimeters)
 - 1. Base Course : 2.0 - 5.0
 - 2. Wearing Course : 2.0 - 4.0
 - c. Voids in total mix (percent)

1. Base Course : 3.0 - 7.0
 2. Wearing Course : 3.0 - 5.0
 - d. Voids filled with Asphalt (percent)
 1. Base Course : 60.0 - 75.0
 2. Wearing Course : 70.0 - 80.0
 - e. Voids in mineral aggregate (percent)
 - (1) Minimum 14 percent
 - f. Loss of Marshall stability by submerging specimens in water at 60°C for 24 hours as compared to stability measured after submersion in water at 60°C for 20 minutes in accordance with MIL-STD-620A, Method 104:
 - (1) Maximum of 25 percent
 - g. Aggregates shall not show evidence of stripping when tested in accordance with ASTM D 1664. Coated area shall be greater than 95 percent. Hydrated lime, Portland Cement or an approved anti-stripping agent shall be used to reduce asphalt stripping and loss of stability. Determine the most effective additive, which shall be approved by the Engineer prior to use.
 - h. Dune sand added to the mixture shall not exceed 10 percent of the total weight of the blended aggregate.
 4. When tested in accordance with ASTM D 1560 the bituminous mixture shall have a Stability of 37 or more.
- B. Variations From Job Mix Based on the Results of Single Test: Variation from the approved job mix shall not exceed the following:
1. Aggregates Passing 4.75 mm (No. 4) and Larger: Plus or minus 7 percent
 2. Aggregates Passing 2 mm (No. 10), & 0.425 mm (No. 40): Plus or minus 4 percent
 3. Aggregates Passing 0.25 mm (No. 80) and 0.075 mm (No. 200): Plus or minus 2 percent
 4. Asphalt Content: Plus or minus 0.4 percent
 5. Temperature Range: Plus or minus 11°C
- C. Select asphalt content so that the air voids will not fall below three percent

after allowance is made for job tolerance of plus or minus 0.4 percent.

2.03 Asphalt pavement layers system shall be as indicated in drawings and as following:

A. One layer System

1. Sub-Grade
2. Granular Sub-Base
3. Prime Coat
4. Wearing Coarse

B. Two layers system

1. Sub-Grade
2. Granular Sub-Base
3. Prime Coat
4. Base Coarse
5. Tack Coat
6. Wearing Coarse

3. PART 3 - EXECUTION

3.01 SUB-GRADE PREPARATION

A. Conform to Section 02200 - EARTHWORK.

3.02 GRANULAR SUB-BASE

A. Conform to Section 02200 - EARTHWORK.

3.03 BATCHING AND MIXING OF BITUMINOUS CONCRETE

A. Batching and Mixing: Mixing plants shall conform to ASTM D 995. Truck scales shall be provided by Contractor.

1. Preparation of Asphalt Cement: Heat asphalt cement within a temperature range of 135°C to 163°C at the time of mixing. All material heated above 204°C shall be rejected.

2. Preparation of Mineral Aggregate

- a. Heat and dry aggregates to a temperature after screening of not more than 163°C. If the aggregates contain sufficient moisture to cause foaming in the mixture, or if their temperature is in excess of 163°C, they shall be rejected and removed from the bins.
- b. Immediately after heating, screen aggregates into at least three sizes and convey into separate bins ready for batching and mixing. Screening operation shall produce gradations of heated and dried aggregates which are reasonably uniform and result in the production of a mixture as specified.

3. Preparation of Bituminous Mixture

- a. Introduce aggregates and asphalt cement into the mixture in proportionate amount according to the job-mix formula. The combined aggregate shall not contain more than one percent moisture. The temperature of the asphalt shall be not less than 32°C below the temperature of aggregate at the time the materials enter the mixer or pug mill.
- b. Use the shortest mixing time that will produce a satisfactory mixture. Use the procedure for determining the percentage of coated particles described in ASTM D 2489. The mixing times shall be set to achieve 95 percent of coated particles for all mixtures.
- c. For batch plants, dry mixing time, if necessary, shall not exceed 10 seconds. Wet mixing time shall not exceed 50 seconds. For batch plants, wet mix timing shall begin at the start of the asphalt introduction into the pug mill.

3.04 PREPARATION OF SURFACE

- A. Proof roll prepared subbase surface to check for unstable areas and areas requiring additional compaction.
- B. Notify the Engineer of unsatisfactory conditions, if any. Do not start paving work until deficient subbase areas have been corrected and are ready to receive paving.
- C. Prior to application of bituminous material, remove loose materials from the underlying surface and clean such surface using approved mechanical sweepers, blowers, and hand brooms.

3.05 PRIME COATS AND TACK COATS

- A. General

1. Prime Coat (MC-1): Apply liquid asphalt on previously constructed subgrade, subbase, or base course at a rate from 0.65 l/m² to 1.75 l/m² as approved. Apply prime coat up to a line 200 mm outside the edge of the pavement line.
2. Tack Coat (RC-2): Apply liquid asphalt on previously constructed bituminous concrete surfaces (between layers) at a rate from 0.10 l/m² to 0.35 l/m² as approved.
3. Temperature: Apply liquid asphalt at temperatures within the range of 50°C to 70°C. Reject materials heated to temperatures above 108°C until the material can be re-sampled and retested.

B. Application

1. Apply by approved pressure distributors. Spray nozzles and spray bar shall be adjusted and frequently checked to ensure uniform distribution. Stop spraying upon clogging or interference of any nozzle, and take corrective measures before resuming.
2. Hand sprays will be approved only for priming small patches or areas that cannot be primed by normal operation of the distributor.
3. Application at the junction of spreads shall not be in excess of the specified amount. Squeegee excess from the surface and correct skipped and deficient areas by means of approved hand sprayers.
4. Following application, the primed surface shall be allowed to cure not less than 48 hours prior to placement of bituminous concrete mix.
5. Prior to application of tack coat, the surface shall be clean, free of dust, dirt, and other loose material. Tack coat shall be placed not more than 4 hours prior to placement of next layer.

3.06 PLACING OF BITUMINOUS CONCRETE

- A. Underlying course shall be cleaned of loose and deleterious material using a power sweeper and/or hand brooms. The mixture shall be laid only upon an approved underlying course, which is dry and in suitable condition, and when weather conditions are determined to be favorable. A mixture shall not be placed when the air temperature in the shade and away from artificial heat is 4°C or lower, unless required by the Engineer. The Engineer may permit work to continue during inclement weather only to provide for laying that material which is in transit from the plant, provided the mixture is within the temperature limits specified.
- B. Deliver bituminous concrete to the paver at a temperature between 139°C and 163°C. Do not use mixtures delivered to the paver at temperatures outside this range.

- C. Upon arrival, the mixture shall be dumped into an approved bituminous paver and immediately spread to the width required. It shall be struck off in a uniform layer of such depth that, when the work is completed, it will have the required thickness and will conform to the grade and surface contour required. Dumping material in a windrow and then placing the material in the paver with loading equipment will not be permitted. Regulate the speed of the paver to eliminate pulling and tearing of the bituminous mat.
- D. Place the mixture in consecutive, adjacent strips with a minimum width of 3 m except where edge lanes require strips of lesser width. Unless otherwise directed, begin placing along the centerline of crowned sections or on the high side of areas with a one-way slope. After the first strip or width has been compacted, the second width shall be placed, finished, and compacted in the same manner as the first width. After the second strip has been placed and rolled, a 5 m straightedge shall be placed across the longitudinal joint to determine if the surface conforms to grade and contour requirements. If the grade and contour requirements are not as specified, the strip shall be removed and replaced with satisfactory material in sufficient quantity to meet the grade and contour requirements at the end of rolling.
- E. Place bituminous concrete so that after rolling the nominal thickness of each layer will not exceed 100 mm. The top layer shall not exceed 50 mm in thickness.
- F. In areas where because of irregularities or unavoidable obstacles, the use of mechanical spreading and finishing equipment is impractical, the mixture may be hand spread as approved by the Engineer.
- G. Joint: Make joints between old and new pavements, or between successive days work, to ensure continuous bond between adjoining work. Construct joints to have same texture, density and contact surfaces and apply tack coat.

3.07 ROLLING

- A. After spreading, compact mixture thoroughly and uniformly by rolling the surface when the mixture has attained sufficient stability so that rolling does not cause undue displacement, cracking, or shoving. The speed of the roller shall, at all times, be slow enough to avoid displacement of the hot mixture. Displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once.
- B. Begin initial or breakdown rolling as soon as the bituminous concrete will bear the roller without undue displacement. Roll longitudinally on the first strip laid, rolling shall start in the center and continue toward either edge. On subsequent strips, rolling shall start on the edge adjacent to previously laid material and continue toward the opposite edge. Overlap successive trips by at least one half the drum width. Alternate trips of the roller shall

be of different lengths.

- C. To prevent adhesion of the mixture, moisten the roller drums with water; an excess of water will not be permitted.
- D. Follow initial or breakdown rolling by rolling with a pneumatic-tired roller. Perform finish rolling with a tandem roller. Number and size of rollers shall be selected to obtain the specified density.
- E. Operate rollers continuously so that all areas of the pavement will receive substantially equal compaction. Placing will be ordered to stop at any time that proper rolling is not being performed.
- F. Make surface tests to check conformity with the specified crown and grade immediately after initial rolling. Correct any variation by the removal or addition of materials and by continuous rolling. The finished surface shall not vary by more than the specified tolerances. After the completion of final rolling, retest the smoothness of the course. Immediately correct all humps or depressions exceeding the specified tolerances, as approved. Replace the pavement where holes are made for test purposes.
- G. In areas not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers. Any mixture which becomes loose and broken, mixed with dirt, or in any way defective shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. Skin patching will not be permitted.
- H. Patching: Remove and replace paving areas mixed with foreign materials and defective areas. Cut-out such areas and fill with fresh, hot asphalt concrete. Compact by rolling to maximum surface density and smoothness.
- I. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.08 FIELD QUALITY CONTROL

A. Dimensional Tolerances

- 1. Surfaces: Variation of the surface when tested with a 5 m straightedge shall not exceed 6 mm when a straightedge is placed parallel or at right angles to the centerline.
- 2. Elevations: Variations from grade line, elevations and cross sections shall not exceed 13 mm above or 6 mm below the elevations shown.
- 3. Thickness: Variations in thickness shall not exceed a tolerance of plus or minus 13 mm.

- B. Test Sampling: For every 500 metric tones of asphaltic material produced, the following tests will be performed by the Contractor through independent testing laboratory.

1. For Plant Control

- a. Two hot bin gradations of aggregate sampled in accordance with ASTM D 75.
- b. Two sets of Marshall specimens prepared from hot asphaltic mixture taken from truck.
- c. Two asphalt content from hot asphaltic mixture taken from truck.
- d. Two sets of Hveem Stability specimens prepared from hot asphaltic mixture taken from the truck.

2. For Density and Thickness Control

- a. Four samples taken from in-place pavement and representing 500 metric tones, except that no more than 24 samples shall be taken in any one day.

Samples for determining density and thickness may be taken with either a coring machine or by cutting out a section with a concrete saw. Core bored or cut holes shall be filled with approved material and compacted to the required density.

- b. Sampling frequency may be varied at the discretion of the Engineer.

3. Additional tests, if required by the Engineer, shall be carried out by the Contractor without any extra cost to the Owner.

- C. Minimum Test Requirements: In case the work involves production of less than 500 metric tones of asphaltic material per day, the following tests will be performed by the Contractor through an independent testing laboratory.

1. For Plant Control

- a. One hot bin gradations of aggregate sampled in accordance with ASTM D 75.
- b. One sets of Marshall specimens prepared from hot asphaltic mixture taken from truck.
- c. One asphalt content from hot asphaltic mixture taken from truck.

- d. One sets of Hveem Stability specimens prepared from hot asphaltic mixture taken from truck.
 2. For Density and Thickness Control
 - a. Four samples taken from in-place pavement each day. Samples for determining density and thickness may be taken with either a coring machine or by cutting out a section with a concrete saw. Core bored or cut holes shall be filled with approved material and compacted to the required density.
 - b. Sampling frequency may be varied at the discretion of the Engineer.
 3. Additional tests, if required by the Engineer, shall be carried out by the Contractor without any extra cost to the Owner.
- D. Testing: Tests shall be performed in accordance with the requirements of the following:
 1. Mechanical Analysis of Extracted Aggregate: AASHTO T30.
 2. Resistance to Plastic Flow of Bituminous Mixture: ASTM D 1559.
 3. Extraction of Bitumen from Bituminous Paving Mixtures: ASTM D 2172, Method A or B, as required.
 4. Bulk Specific Gravity of Compacted Bituminous Mixtures: ASTM D 2726.
 5. Thickness of In-Place Pavement: Determined by average caliper measurement of samples in accordance with ASTM D 3459.
 6. Theoretical Maximum Specific Gravity of bituminous Paving Mixtures: ASTM D 2041.
- E. Acceptance
 1. A lot is defined as one-half day's production. Maximum size of a lot will be about 500metric tone.
 2. Acceptance of the compacted pavement with respect to density shall be based on the average of four laboratory density determinations for each lot. Cores drilled from the pavement shall be used to test the density of the layer by either ASTM D 1188 or ASTM D 2726, as applicable. Each lot of the compacted pavement shall be accepted when average density determinations are equal to or greater than 97 percent of the average density of the four laboratory-prepared specimens with no single value less than 95 percent.

3. The location of sampling sites within a lot's placement area shall be chosen on a random basis. At least 25 percent of the core samples shall be obtained from joints. The same cores used to test the density shall be used to measure the thickness of the pavement.

END OF SECTION

SECTION 02515

UNIT PAVERS

1. PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. External paving units and the related setting materials as indicated on Drawings and as specified in this section.

1.02 REFERENCES

A. ASTM - American Society for Testing and Materials

ASTM C 33	Specification for Concrete Aggregates
ASTM C 144	Specification for Aggregate for Masonry Mortar
ASTM C 150	Specification for Portland Cement
ASTM C 207	Specification for Hydrated Lime for Masonry Purposes
ASTM C 270	Specification for Mortar for Unit Masonry
ASTM D 1751	Specification for Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types)

- B. Refer to the applicable Codes and Standards of the following Sections:

- 1. Section 03300 - CAST-IN-PLACE CONCRETE.
- 2. Section 07900 - SEALANTS.

1.03 SUBMITTALS

- A. Product Data: Submit manufacturer's technical data for unit pavers including test results and certificates showing that units conform to the specified requirements.
- B. Samples: For initial selection of quality, color, finish and texture submit unit paver samples showing full range of colors and textures available as well as compliance with the specified requirements. Furnish samples made up of full-size units.
- C. Field Constructed Mock-Up: Provide a mock-up for each type of unit pavers and application required.

1.04 QUALITY ASSURANCE

- A. Comply with the applicable requirements specified in Division 2 - SITEWORK and Division 3 - CONCRETE with respect to materials, tests, quality assurance and workmanship.

2. PART 2 - PRODUCTS

2.01 MATERIALS

A. Precast Concrete Tile Pavers

1. Units shall have solid construction, manufactured by hydraulic pressing of mortar and concrete in 2 layers; upper layer formed of 10 mm thick 1-1 cement-sand mortar by volume and lower layer formed of 30 mm thick concrete with compressive strength of 30 MPa after curing.
2. Concrete shall comply with Section 03300 - CAST-IN-PLACE CONCRETE.
3. Concrete tiles shall have maximum water absorption of 5 percent.
4. Precast concrete tiles shall be manufactured in a fully automatic plant using latest technique for batching, placing and curing concrete.
5. Finished elements shall be sound in appearance with clean planar surfaces, free from segregation, honey combing, pits, cracks, broken edges or corners.
6. Size of tiles shall be as indicated on Drawings. Color and texture shall be as selected and approved by the Engineer.
7. Precast concrete tile pavers will be either fixed by mortar on reinforcement concrete base or loose laid spaced with round edge pea gravel aggregates with diameter size of 15 - 30 mm and total layer thickness of 40 mm all on sand bed as shown and indicated on the Drawings.

B. Precast Concrete Interlocking Pavers and Steps

1. Units of a solid construction, shape as indicated on Drawings and manufactured using 30 MPa portland cement concrete with type V cement under hydraulic pressing and high frequency vibration.
2. Units shall have minimum compressive strength 58 Mpa and water absorption of maximum 5 percent.
3. Sizes of pavers shall be as indicated on Drawings. Color and texture

shall be as selected and approved by the Engineer.

- C. Concrete Paving/Walkways: Comply with the requirements of Section 02500 - CONCRETE WALKWAYS.
- D. Ceramic Paving and Steps: Comply with the requirements of Section 09310 - CERAMIC TILES.
- E. Granite for External Paving and Steps
 - 1. Granite pavers shall have a honed or flamed finish and shall be of the sizes, texture, type, color, and shapes indicated on the drawings.
 - 2. Granite For paving and steps thickness shall be as indicated on Drawings and shall comply with Section 09600 - STONE WORK.
- F. Concrete Brick Pavers and steps: Shall be solid units made from 30 MPa concrete with type V Portland cement. Units shall be manufactured under hydraulic pressing and high frequency vibration. Units shall have compressive strength of greater than 58 MPa and water absorption of maximum 5%. Sizes and shapes shall be as shown on drawings.
- G. Concrete Brick Edging and Banding: Shall be solid units made from 30 MPa concrete with type V Portland cement. Units shall be manufactured under hydraulic pressing and high frequency vibration. Units shall have compressive strength of greater than 58 MPa and water absorption of maximum 5%. Sizes and shapes shall be as shown on drawings.
- H. Concrete Mowing Edge/Flush curb: Shall be solid units made from 30 MPa concrete with type V Portland cement. Units shall be manufactured under hydraulic pressing and high frequency vibration. Units shall have compressive strength of greater than 58 MPa and water absorption of maximum 5%. Sizes and shapes shall be as shown on drawings.
- I. Expansion Joint Filler: Asphalt saturated fiber board conforming ASTM D 1751.
- J. Joint Sealant: Refer to Section 07900 - SEALANTS.

2.02 SETTING MATERIALS

- A. Ungrouted Mortarless Setting Materials
 - 1. Sand for Setting Beds: Fine aggregates complying with ASTM C 33.
 - 2. Sand for Joints: Complying to ASTM C 144, with gradation for unusual thin joints.
- B. Mortar Application
 - 1. Aggregates: ASTM C 144.

2. Portland Cement: ASTM C 150.
3. Hydrated Lime: ASTM C 207, Type S.
4. Water: Clean and potable.

3. PART 3 - EXECUTION

3.01 INSTALLATION - GENERAL

- A. Do not use paving units with excessive chips, cracks, voids, discolorations or other defects which might be visible or cause staining to finished work.
- B. Cut paving units with motor-driven saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern shown and to fit adjoining work neatly. Use full units without cutting to maximum extent. Hammer cutting is not acceptable.
- C. Set paving units in patterns shown or approved by the Engineer and with uniform joints of width as indicated on the Drawings. Expansion joints shall be provided at returns and interface with other finishes in conformance with the details shown on the Drawings. Provide 6 mm wide expansion joints at intervals not greater than 12 meters.
- D. Tolerances: Do not exceed 3 mm unit-to-unit offset from flush, or exceed a tolerance of 3 mm in 600 mm and 6 mm in 3000 mm from level or slope as indicated for finished surface of paving.

3.02 MORTAR-SET PAVING UNITS

- A. Install units in setting bed of 20 mm thick mortar with grouted joints as shown on the drawings. Mortar mix for setting bed and grouting shall be Type M complying with ASTM C 270, 1-3 cement-sand mortar and not more than 1/4 part lime per part of cement.
- B. Remove excess mortar promptly as work progresses. Lay paving units in pattern shown with straight, uniform joints. Level surface to the elevations shown. Strike joints down from the top surface of paving unit. Cure mortar by maintaining in damp condition for 7 days. Brush dry mix cement sand mortar into joints and lightly water upon completion ensuring there is no shearing of mortar on the finished work.

3.03 SAND-SET PAVING UNITS

- A. Place concrete pavers on a sand bed of thickness as indicated on drawings. Set paving units in the indicated patterns placing each paver as close as possible to the adjacent pavers. Vibrate into position to even running levels using plate vibrator capable of 1590 to 2272 kg compaction core. Sweep fine sand over surface to fill joint irregularities after vibration. Surface of pavement shall be true to levels and grades with a tolerance of 5 mm in 3 m.

3.04 REPAIR AND PROTECTION

- A. Remove and replace paving units which are loose, chipped, broken, stained or otherwise damaged, or if units do not match adjoining units as intended. Provide new units to match adjoining units and install in same manner as original units with same joint treatment to eliminate evidence of replacement.
- B. Pointing: During tooling of joints, completely fill all enlarge voids or holes with mortar and grout. Point-up joints at sealant type joints to provide a neat, uniform appearance, properly prepared for application of sealant.
- C. Cleaning: Remove excess mortar or grout from the exposed surfaces then wash and scrub clean.
- D. Protect paving work from deterioration, discoloration or damage during subsequent construction and until the final acceptance of work in accordance with the recommendations of the paving unit manufacturer.

END OF SECTION

SECTION 02525

PRECAST CONCRETE CURBS

1. PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Precast concrete curbs for driveways as indicated on Drawings.
- B. Precast concrete wheel stoppers

1.02 REFERENCES

- A. Conform to the applicable requirements specified in Section 03300 - CAST-IN-PLACE CONCRETE.

1.03 SUBMITTALS

- A. Shop drawings indicating all dimensions of modules proposed for use, including composition of the various elements.
- B. Copies of all test reports indicating mix components and test results in compliance with specification requirements.
- C. The Contractor shall submit samples of precast concrete curbs and stoppers for approval of quality, color, finish and texture.

1.04 QUALITY ASSURANCE

- A. Conform to the applicable requirements of the following Divisions:
 - 1. Division 2 - SITEWORK
 - 2. Division 3 - CONCRETE

For the requirements of materials and workmanship, testing and quality assurance.

2. PART 2 - PRODUCTS

2.01 MATERIALS

- A. Materials used shall conform to the requirements of Section 03300 - CAST-IN-PLACE CONCRETE.
- B. Precast Concrete Curbs

1. Construction: Manufacture precast curbs using Class 30 concrete conforming to the requirements of Section 03300 - CAST-IN-PLACE CONCRETE. Portland cement shall conform to SSA 143 or ASTM C 150.
2. Size: 500 x 300 x 150 and as indicated on Drawings.
3. Fabrication: Concrete curbs shall be manufactured by hydraulic pressing in an approved machine using concrete produced in a fully automatic batching plant. Finished elements shall be of sound appearance with clean planar faces, free from segregation, honeycombing, pits, broken corners and other defects. Bullnoses and curved faces shall be of constant radius with a smooth change from radius to plan face. Manufacturing tolerances shall be 3 mm in any one dimension and end faces shall be truly perpendicular to the base.

C. Precast Concrete Wheel Stopper:

1. Construction: Manufactured from 30 MPa concrete using type I cement conforming to the requirements of Section 03300 - CAST-IN-PLACE CONCRETE. Size and shape shall be as shown on the Drawings or as approved by the Engineer. Provide the finished elements with sound appearance and clean planar faces, free from segregation, honeycombing, pits, broken corners and other defects.
2. Grout: As approved by the Engineer.
 - a. Construction: High strength, non-shrink cementitious grout, ready-to-use, supplied in powder form and requires only on-site addition of water to produce non-shrink grout of predictable performance.

3. PART 3 - EXECUTION

3.01 INSTALLATION

- A. Elements shall be set out to lines and grades as shown. Under no circumstances shall levels be set by direct measurement.
- B. Foundation shall be excavated to the grades and sections shown and fully compacted and rolled to a smooth surface. Concrete shall not be placed until the foundation has been approved.
- C. Elements shall be laid either directly on a wet concrete base or on 1-3 cement-sand mortar bed, 20 mm thick on a previously laid concrete base. Base shall be constructed of Class 20 concrete conforming to the

requirements of Section 03300-CAST-IN-PLACE CONCRETE.

- D. After elements have been laid, continuous concrete backing shall be poured. Backing concrete shall be of Class 20 conforming to the requirements of Section 03300 - CAST-IN-PLACE CONCRETE.
- E. Joints between curbs and paving tiles shall have a width of 4 mm, filled with 1-1 cement-sand mortar with one fifth hydrated lime and sufficient water to make the mixture plastic and easily smoothed and finished.
- F. A grooving tool shall be used to produce a smooth semi-circular groove not more than 3 mm deep in all joints.
- G. Precast Concrete Wheel Stoppers: Unless otherwise indicated on Drawings, secure wheel stops to the asphalt concrete surfaces using 19 mm diameter galvanized steel dowels embedded in precast units (minimum 2 dowels/unit). Grout dowels using the approved cementitious grout.

3.02 TOLERANCES

- A. Curbs/Wheel stops: Laid to the lines and grades shown on Drawings with a tolerance of plus or minus 3 mm.

END OF SECTION

SECTION 02580

PAVEMENT MARKING

1. PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Paints and thermoplastic markings and coats for traffic and playground pavements as shown on Drawings and as specified in this section.

1.02 REFERENCES

- A. AASHTO - American Association of State Highway and Transportation Officials

AASHTO M 247 Glass Beads Used in Traffic Paint

AASHTO M 249 Thermoplastic Stripping Material, White and Yellow

- B. ASTM - American Society of Testing and Materials

ASTM D 1214 Sieve Analysis of Glass Spheres

- C. FS - Federal Specification

FS TT-B-1325 Beads (Glass Spheres), Retro Reflective

FS TT-P-110 Paint, Traffic (Non-Reflectorized)

FS TT-P-115 Paint, Traffic Highway, White and Yellow

1.03 SUBMITTALS

- A. Product Data: Submit manufacturers technical data and complete information including technical performance data, preparation and application instruction and maintenance and repair recommendation for each type of material.
- B. Certificate of compliance.
- C. Samples: Submit samples of proposed thermoplastic material and glass beads with test reports in accordance with requirements of MOC Standards for Road Safety Features.

1.04 TRANSPORTATION, HANDLING AND STORAGE

- A. Marking materials and glass beads shall be supplied and delivered to the project in manufacturer's original new and unopened containers, factory sealed and labelled. The containers containing marking materials shall be

sealed to preclude contamination and shall have a capacity of not less than 25 kg nor more than 100 kg and each container shall be labelled to clearly identify the following informations:

- Name or title of material.
- Manufacturer's stock number and date of manufacture.
- Manufacturer's name.
- Contents by volume.
- Thinning instructions.
- Application instructions.
- Color name and number.

- B. Containers of marking materials shall not be opened except for immediate use. Materials older than the manufacturer's recommended or extended shelf life shall not be used and shall be removed from the site.
- C. Provide adequate storage facilities separate from storage of other building materials. Store materials at a minimum ambient temperature of 7°C in a well ventilated area. Also, follow manufacturer's written instructions regarding storage and handling.

1.05 QUALITY ASSURANCE

- A. Single Source Responsibility: Provide pavement marking materials produced by single manufacturer. Application shall be as per manufacturer's instructions and recommendations.
- B. Marking materials shall be specifically designed and formulated for pavement work of types required and climate conditions applicable. Materials shall be manufacturer's standard materials of the kinds required, and shall have successful use proven in similar applications.
- C. Provide manufacturer's best quality trade materials. Container not displaying manufacturer's product identification will not be acceptable.

2. PART 2 - PRODUCTS

2.01 MATERIALS

- A. Pavement Markings: Material used for all traffic stripes and markings shall be reflectorizing thermoplastic type complying with the requirements of AASHTO 249 and MOC Standards. Marking materials shall comprise of synthetic hydrocarbon thermoplastic resins, plasticizer, extenders, pigments, aggregate, and pre-mixed reflectorizing glass beads; and shall have surface applied glass beads to marking material at the time it is applied to the pavement.
- B. Marking Material: Designed for dry film thickness of not less than 1.5 mm, exclusive of surface applied glass beads. Color of marking material shall

be white and yellow unless otherwise indicated on Drawings.

- C. Glass Beads: Reflective feature shall be provided by adding glass spheres to surface of thermoplastic coating. Glass spheres (beads) shall be as recommended by thermoplastic coating manufacturer, shall conform to AASHTO M 247 except as specified herein, and shall be capable of reflectorizing the approved thermoplastic coating effectively. Beads shall be transparent, reasonable spherical and colorless, and shall not impart color to the thermoplastic. Bead sizes shall conform to the following gradation, as determined by ASTM D 1214:

Sieve Size	Percent Passing
0.250 mm	100
0.212 mm	85 - 100
0.106 mm	15 - 55
0.063 mm	0 - 10

3. PART 3 - EXECUTION

3.01 CONSTRUCTION METHODS

- A. Time of Application: Allow at least 30 days curing time for new pavement surfaces before applying paint.
- B. Weather Limitations: Perform painting only when the existing surface is dry and clean, when the pavement and air temperatures are above 4°C and below 50°C and when weather is not too windy, dusty, or foggy for to protect satisfactory painting.
- C. Sample Painting: If required by the Engineer, paint a sample pavement strip of 45 m length at an approved location. The sample shall demonstrate that the materials, equipment, and application methods will provide specified results. Proceed with work only after the methods established in the sample have been approved.
- D. Layouts and Alignment: On sections of pavements where no previously applied figures, markings, or stripes are available to serve as a guide, spot the layouts and lines of proposed stripes in advance of the painting thermoplastic stripping. Space control points to ensure the accurate location of all markings.
- E. Equipment for Painting:
1. Equipment will be subject to approval of the Engineer, and shall include apparatus for cleaning the existing surface, a mechanical marking machine, and auxiliary hand-painting equipment.

2. Mechanical marker shall be an atomizing spray-type marking machine for applying traffic paint and shall produce a film of uniform thickness at the required coverage rate. Markings shall be of uniform cross-section, shall have clear-cut edges without runs or spatters, and shall be within the specified limits for straightness. When needed, furnish a reflective media dispenser for attachment to the mechanical marker.
 3. Provide adjustments on the sprayers of a single machine to paint the width required, or furnish additional equipment.
 4. Hydrocarbon thermoplastic traffic strips shall be applied with an approved extrusion machine capable of applying the thermoplastic to the required width in accordance with manufacturer's written recommendations.
- F. Preparation of Surface:
1. Immediately before applying paint, clean the pavement by sweeping and blowing as necessary to produce a dry surface free from substances such as dirt, grease, oil, acid, and other substance which will reduce bond between markers and the pavement. Scrub areas which cannot be satisfactorily cleaned by brooming and blowing, as required, to be treated with a 10 percent solution by weight of trisodium phosphate in water or other approved solution. After scrubbing, rinse the solution off and dry the surface before painting or application of thermoplastic.
 2. Spot the layouts and lines of proposed stripes on pavement in advance of the paint application. Space control points to ensure accurate location of all markings.
- G. Application of Paint or Thermoplastic:
1. Apply markings in the locations shown and in conformance with the dimensions, spacings, and colors shown, or as required. Do not apply paint until the layouts, indicated alignment, and the condition of the existing surface are approved.
 2. Apply single stripes wholly on one side of longitudinal pavement joints. Center double or multiple stripes over such joints.
 3. Mix the paint in accordance with the manufacturer's written instructions and apply it to the surface of the pavement with the marking machine at its original consistency without the addition of thinner. Use pneumatic spray guns for hand application in areas where mobile paint applicator cannot be used. Do not use brushes to apply paint. Thermoplastic shall be applied in accordance with manufacturer's recommendations.
 4. When reflectorized markings are applied, distribute the reflective

media to the surface of the pigmented binder immediately, and imbed at the required rate.

5. Make sure that the paint does not bleed excessively, curl, or discolor when it is applied to bituminous surfaces.
6. When painting straight stripes, obliterate deviations in the edges exceeding 13 mm in 15 m and correct the markings. The widths of the markings shall be as indicated, within a tolerance of plus or minus five percent. Perform painting or application of thermoplastic as approved.
7. Apply paint uniformly with satisfactory equipment at the rate of not less than 2.60 m²/l nor more than 2.80 m²/l. Apply glass spheres at the rate of 1.2 kg/l of paint.
8. Hydrocarbon thermoplastic strip shall be extruded to a finished thickness of 2.3 mm by an approved extrusion machine. Glass beads shall be applied in accordance with the MOC standards.

H. Application of Glass Beads:

1. For roadway pavement markings, the amount of beads (glass spheres) in the finished paint shall contain not less than 0.5 kg/l nor more than 0.59 kg/l.
- I. Protection of Markings: Protect fresh paint and markings while paint dries. Erect satisfactory warning signs, flags or barricades, protective screens, and coverings as required. Protect surfaces from disfiguration spatter, spillage, or drippings of paint, thermoplastic, or other materials.

END OF SECTION

SECTION 02820

CHAIN LINK FENCES AND GATES

1. PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Fence framework, fabric, and accessories.
- B. Manual gates and related hardware.

1.02 REFERENCES

A. ASTM - American Society for Testing and Materials

ANSI/ASTM A123 Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products.

ANSI/ASTM F567 Installation of Chain-Link Fence.

ASTM A 116 Zinc-Coated (Galvanized) Steel Woven Wire Fence Fabric.

ASTM A 120 Pipe, Steel, Black and Hot-Dipped Zinc Coated (Galvanized) Welded and Seamless, for Ordinary Uses.

ASTM A 121 Zinc-Coated(Galvanized)Steel Barbed wire

ASTM A 153 Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

ASTM A 392 Zinc-Coated Steel Chain-Link Fence Fabric.

ASTM A 428 Weight of Coating on Aluminum-Coated Iron or Steel Articles.

ASTM A 491 Aluminum-Coated Steel Chain Link Fence Fabric.

ASTM A 569 Steel, Carbon (0.15 Maximum Percent), Hot-Rolled Sheet and Strip Commercial Quality.

ASTM A 585 Aluminum Coated Steel Barbed Wire.

ASTM C 94 Ready-mixed Concrete.

ASTM F 573 Residential Zinc-Coated Steel Chain Link

Fence Fabric.

ASTM F 668 Poly (Vinyl Chloride) (PVC) Coated Steel
Chain Link Fence Fabric.

B. Chain Link Fence Manufacturers Institute (CLFMI)

- Product Manual.

1.03 SYSTEM DESCRIPTION

- A. Fence Height: As indicated on Drawings.
- B. Line Post Spacing: At intervals not exceeding 3 m.

1.04 SUBMITTALS

- A. Shop Drawings: Indicate plan layout, spacing of components, post foundation dimensions, hardware anchorage, and schedule of components.
- B. Product Data: Provide data on fabric, posts, accessories, fittings and hardware.
- C. Samples: Submit 2 samples of fence fabric, 150 x 150 mm in size illustrating construction and color of finish.
- D. Manufacturer's Installation Instructions: Indicate installation requirements, post foundation anchor bolt templates, hardware and accessories.

1.05 QUALITY ASSURANCE

- A. Perform Work in accordance with CLFMI - Product Manual and manufacturer's instructions.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this Section with minimum 3 years documented experience.
- C. Installer Qualifications: Company specializing in installing the products specified in this Section with minimum 3 years documented experience. Installer shall be as recommended manufacturer and approved by the Engineer.

2. PART 2 - PRODUCTS

2.01 MATERIALS

- A. Materials for fencing and gates shall conform to AASHTO M 181 and to the standards specified. All items of each type, such as posts, fabric, and

accessories shall be from the same manufactures and of the same size, design, and materials except as otherwise shown and required.

- B. All ferrous fence materials including wire fabric, all type of posts, gate frames and other accessories shall be coated with extruded polyvinyl chloride (PVC). The color of the vinyl coating shall be green or as approved by the Engineer.
- C. Before PVC coating, all ferrous fence material, except wire fabric, shall be galvanized with a minimum of 550 gm of zinc per square meter. Wire fabric shall be galvanized with a minimum of 52 gm of zinc per square meter.
- D. Wire Fabric: The chain link fence fabric conforming to ASTM A 392 Class I, shall have 50 mm mesh of 4.88 mm core wire, and twisted and barbed top and bottom selvages. The fabric shall be of width as shown on the drawings.
- E. Posts and Miscellaneous Metals:
 - 1. Line posts shall be standard galvanized steel posts of not less than 50 mm outside diameter conforming to ASTM A 120, Schedule 40, weighing not less than 5.44 kg/m, and section modules of 9190 mm³ minimum. Other shapes may be substituted provided that the section modules is maintained or exceeded.
 - 2. End, corner and pull posts shall be standard galvanized steel posts of not less than 73 mm outside diameter conforming to ASTM A 120, Schedule 40, weighing not less than 8.62 kg/m and section modulus of 1744 mm³ minimum. Other shapes may be substituted provided the section modulus is maintained or exceeded.
 - 3. Gate hinge posts shall be standard galvanized steel pipe conforming to ASTM A 120, Schedule 40 with the following minimum diameters and weights for the nominal widths of a single gate, or for one leaf of a double gate:

NOMINAL GATE WIDTH (m)	OUTSIDE DIAMETER(mm)	WEIGH T (kg/m)	MINIMUM SECTION MODULES (mm ³)
Over 1.80 to 4.00	101.6	13.56	39200
Over 4.00 to 5.50	168.3	28.25	139300
Over 5.50 to 8.00	219.1	42.55	240700

- 4. Post tops, and other fittings and hardware shall be of bonded vinyl coated steel, malleable iron, or wrought iron.

5. Top and bottom tension wires between posts shall be at least 4.88 mm diameter extruded vinyl-coated galvanized steel with a minimum breaking strength of 8 kN. Tie wire shall be 2.0 mm diameter extruded vinyl-coated galvanized steel, conforming to ASTM A112.
 6. Stretcher bars shall be of vinyl coated steel, not less than 6 mm by 20 mm, and of lengths equal to the full height of the fabric to be used.
 7. Bolts, nuts and other hardware shall be galvanized steel, coated with PVC after assembly.
 8. Horizontal truss braces shall be vinyl coated steel pipe at least 42.2 mm outside diameter weighing not less than 3.38 kg/m and with a section modulus of 3851 mm³ minimum. Other steel shapes may be substituted provided that the section modulus is equalled or exceeded. Vinyl coated steel truss rods at least 10 mm diameter with turn buckles shall be used for diagonal bracing.
- F. Gates:
1. Swing gate frames as shown shall be bonded vinyl-coated galvanized standard steel pipe of not less than 48.3 mm outside diameter conforming to ASTM A 120, Schedule 40, weighing not less than 4.05 kg/m and with a section modulus of 5340 mm³ minimum. Joints to form a rigid frame. Cross-braces shall be vinyl-coated galvanized steel rods, 10 mm in diameter as shown. Bonded vinyl-coated steel or malleable iron hinges shall be not less than 75 mm wide.
 2. Latches for swing gates shall have padlock eyes and shall be the forked or plunger-bar type, operated from each side of the gate. Provide gate stops and keepers as required.
 3. Guides, rollers, hinges, and track shall be the manufacturer's standard of a type which will ensure that gates cannot be readily detached by unauthorized persons.
 4. Tie wire and stretcher bars as specified for other fencing herein.
- G. Concrete for Foundations: In accordance with the requirements specified in Section 03300 - CAST-IN-PLACE CONCRETE, Class 30.

3. PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install framework, fabric, accessories and gates in accordance with ANSI/ASTM F 567 and manufacturer's instructions.

B. Posts:

1. Line posts shall be spaced not more than 3 m apart, measured parallel to the slope of the natural ground. Place posts vertical except in unusual situations as determined by the Engineer where posts shall be placed perpendicular to the slope of the ground.
2. Gate posts shall be installed where required by design. Corner posts shall be installed where the change in direction is 15 degrees or more.
3. Pull posts shall be placed not more than 180 m apart in a straight run and where the line changes direction by 15 degrees or more.

C. Set posts and intermediate gate posts plumb, in concrete footings with top of footing 50 mm above finish grade. Slope top of concrete for water runoff.

D. Footing depth below finish grade: As indicated on Drawings.

E. Braces:

1. Provide braces, consisting of a horizontal pipe and a diagonal rod, at each gate, corner, pull and end post at midheight of the fabric.
2. The pipe shall extend horizontally between the gate, corner, pull or end post and the adjacent line post. The diagonal rod with a turnbuckle shall be not less than 10 mm in diameter, and shall extend from the line post end of the horizontal pipe to the base of the gate, corner, pull or end post.
3. Where fence lengths 90 m or longer end at gate, corner, pull or end posts, fit a second similar diagonal rod from the midpoint of the gate, corner, pull or end post to the top of the adjacent line post.

F. Provide top rail through line post tops and splice with 150 mm long rail sleeves.

G. Install center and bottom brace rail on corner gate leaves.

H. Stretch fabric between terminal posts or at intervals 30 m maximum, whichever is less.

I. Position bottom of fabric 50 mm above finished grade.

J. Fasten fabric to top rail, line posts, braces, and bottom tension wire with tie wire at maximum 380 mm on centers.

K. Attach fabric to end, corner, and gate posts with tension bars and tension bar clips.

- L. Install bottom tension wire stretched taut between terminal posts.
- M. Install support arms sloped and attach barbed wire; tension and secure.
- N. Install gate with fabric and barbed wire overhang to match fence. Install three hinges per leaf as a minimum unless otherwise required by leaf size, latch, catches and drop bolt.
- O. Provide concrete center drop to footing depth and drop rod retainers at center of double gate openings.

3.02 ERECTION TOLERANCES

- A. Maximum Variation From Plumb: 6 mm.
- B. Maximum Offset From True Position: 25 mm.

END OF SECTION

SECTION 02900

LANDSCAPING

1. PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Landscaping work as shown on Drawings and as specified in this section but shall not be limited to the following:
 - 1. Site Preparation to receive soil and plant materials.
 - 2. Procurement, protection and importation of plant materials to site.
 - 3. Propagation of plant materials.
 - 4. Soil importation.
 - 5. Soil preparation including soil ameliorants.
 - 6. Finish grading of soil.
 - 7. Installation of plant material, trees, shrubs, ground covers, and grass seeds.
 - 8. Staking and guying of trees.
 - 9. Protection, maintenance and guarantee as specified.
 - 10. Watering during construction and maintenance period.
 - 11. Providing all labor and materials incidental to the satisfactory completion of the work, including clean up of the site.
- B. Related Work Items: Refer to the applicable Sections of DIVISION 2 - SITEWORK.

1.02 REFERENCES

- A. AAN - American Association of Nurserymen:
AAN - Botanical Listing, Tagging and sizes.
- B. ACJHN - American Joint Committee on Horticultural Nomenclature:
ACJHN - Latest Edition of Standardized Plant Names.

- C. ANSI - American National of Standards Institute:
Z60.1 - American Standard for Nursery Stock
- D. ASTM - American Society for Testing and Materials:
ASTM C 136 - Sieve or Screen Analysis of Fine and Coarse Aggregates
- E. AOAC - Association of Official Analytical Chemists:
AOAC - Official Methods of Analysis.
- F. Royal Horticultural Society:
Dictionary of Gardening.

1.03 SUBMITTALS

- A. Laboratory Analysis: Testing laboratory analysis shall provide specific testings for each item specified herein, expressed in rates and quantities as required.
- B. Plant Certificates: Submit plant health and import certificates for review and approval.
- C. Plant Supplies: Submit details of sources of supply for trees, shrubs, ground covers, and grass seeds for review and approval. Make necessary arrangements for the Engineer to inspect plant material at the nurseries.
- D. Agricultural Soil and Red Sand Supplies: Submit details of supply and certificates for each delivery of bulk material, including soil and sand, stating the source, quantity, and type of material.
- E. Furnish complete agricultural soil and sand suitability analysis from an approved Independent Testing Laboratory at intervals as required by the Engineer for approval.
- F. Furnish the Client a certificate with each delivery of fertilizers and soil conditioners in containers stating source, quantity and type of material, including manufacturer's statement at testing that the material meets the requirements of the specifications.
- G. Miscellaneous Materials: Furnish samples of materials to be used in association with the landscaping works.

1.04 TRANSPORTATION, HANDLING AND STORAGE

- A. Secure permission from the Engineer to store plants on Project site. Ensure that planting materials are protected from damage by sun, wind

and construction work.

1.05 WARRANTY AND REPLACEMENT

- A. Guarantee executed Work and materials for a period of one year after completion of planting operations. Replace dying or unhealthy plants after conditions become evident.
- B. Plants used for replacement shall be of same kind and size as specified in Plant List and shall be furnished, planted, and maintained as specified.
- C. Approval and Rejection of Materials:
 - 1. Selection of materials and execution of operations shown on Drawings and Specifications are subject to the approval of the Engineer.
 - 2. The Engineer shall have the right to reject material and work which in his opinion does not meet the requirements of Drawings and Specifications at any stage of the operation.
- D. Substitution of Materials:
 - 1. Before submitting bid, locate necessary materials called for and make sure of their availability for use on job.
 - 2. Contract bids shall be based upon providing specified materials, processes, and products identified in Specifications and/or indicated on Drawings.
 - 3. Substitutes will be permitted only upon submission of proof that specified plants are not obtainable and with authorization of the Engineer.
 - 4. Written requests with nearest available size, variety of plant and price adjustments, to be submitted to the Engineer for approval prior ordering substitute(s).

1.06 JOB CONDITIONS

- A. Establish lines and levels necessary for the location and erection of landscape construction, excavation, filling, and grading work. Verify site measurements with Drawings, and assure the proper fitting of this portion of completed work.
- B. Changes or compensation will not be allowed on account of differences between actual measurements and the dimensions shown on Drawings, but any such differences which may be found shall be submitted to the Engineer for adjustment before proceeding with the work.

- C. Provide watering equipment as required for the work at no extra cost to Owner throughout the construction and maintenance period.
- D. Provide and maintain substantial and adequate protection as may be required to protect new and existing work and items of equipment and furnishings through the entire duration of the work, to the full satisfaction of the Engineer.

2. PART 2 - PRODUCTS

2.01 SOIL AMENDMENTS

A. Soil Mixture Materials:

1. Agricultural Soil:

- a. Agricultural soil to be from an agricultural source outside the limits of the Project and in compliance with the requirements specified herein.
- b. Soil shall have the same relative composition and structure, a friable sandy loam character, and be free of roots, clods and stones larger than 25 mm in greatest dimension, pockets of coarse sand, noxious weeds, sticks, brush and other litter.
- c. Soil shall not to be infested with plant disease organisms, nematodes or other insects, and shall be free from all chemicals harmful to plant and animal life.
- d. Agriculture soil to meet the following requirements as approved by soil analysis.
 - (1) Salinity: Not more than 2 milli-mhos/cm as measured by the saturation extract method.
 - (2) Sodium Absorption Ratio: Not more than 5.
 - (3) PH Value: From 5.5 to 7.5.
 - (4) Boron Concentration in Saturation Extract: Not more than 1 ppm.
 - (5) Silt and Clay Content: Not more than 16 percent by weight.
 - (6) A minimum of 90 percent by weight to pass a 2 mm round hole sieve.
 - (7) Permeability Rate: Minimum 13 mm/hour when tested in

accordance with ASTM D 2434 or other approved methods.

2. Red Sand:

- a. Red sand to be from a source outside the limits of the project and in compliance with the requirements specified herein.
- b. Sand shall be free of roots, clods and stones larger than 25 mm in greatest dimension, pockets of gravel, fine silt, noxious weeds, sticks, brush and other litter and shall not be infested with plant disease organisms, nematodes or other insects, and shall be free from chemicals harmful to plant and animal life.
- c. Red Sand Physical Characteristics:
 - (1) Materials Passing a No. 10 Sieve: 100 percent.
 - (2) Materials Passing a No. 35 Sieve: From 90 to 100 percent.
 - (3) Materials Passing a No. 140 Sieve: From 0 to 10 percent.
 - (4) Materials Passing a No. 270 Sieve: From 0 to 3 percent.
- d. Red Sand Chemical Characteristics:
 - (1) Salinity: Not exceeding 2 milli-mhos/cm as measured by the saturation extract method.
 - (2) Sodium Absorption Ratio: Not more than 5.
 - (3) PH Value: From 5.5 to 7.5.

3. Water Retaining Polymer: Non-toxic, bio-degradable polyacrylamide co-polymer which ameliorates the soil by its water storing capacity.

B. Organic Amendments:

1. Submit a written request for approval accompanied by a written report of a testing agency registered by the governing authority for the agricultural evaluation, which states that the proposed source complies with these specifications. Amendments from sources including, but not limited to, refuse, human or animal waste will be rejected.
2. Organic amendments shall have a consistent composition, moderately acidic, with substantial nitrogen content and low salinity.
3. Amendments shall be free of roots, clods and stones, noxious weeds, sticks, brush and other litter and shall not be infested with

nematodes or other insects or plant disease organisms. Organic amendments shall be supplied to improve the organic content of the soil.

4. Organic amendments shall meet the following additional requirements:

a. Physical Characteristics:

- (1) Material passing 9.51 mm sieve: 100 percent
- (2) Material passing 6.35 mm sieve: 90 - 100 percent
- (3) Material passing 2.38 mm sieve: 50 - 60 percent
- (4) Material passing 0.50 mm sieve: 0 - 10 percent
- (5) Bulk Density: 300 - 400 kg/m³

b. Chemical Characteristics:

- (1) Organic Matter: Greater than 85 percent
- (2) PH Value: 5 - 6.5
- (3) Salinity (ECe x 10³): 0.5 - 2.0
- (4) Total Nitrogen: 0.9 - 2.0
- (5) Available Phosphorous: 100 - 500 ppm
- (6) CEC (meg/100 g): 80 - 120
- (7) Boron (Saturation extract): Less than 5 ppm
- (8) Sodium Absorption Ratio: Less than 2.0

C. Fertilizers:

- 1. Fertilizers shall be commercial, granulated type, uniform in composition, dry and free flowing, and shall be delivered to the site in unopened containers each bearing the manufacturer's name, guarantee, chemical analysis, and weight.
- 2. Fertilizing materials shall be packaged, first grade, commercial quality products identified as to source, type of material, weight, and manufacturer's guaranteed analysis.
- 3. Fertilizing materials shall not contain toxic ingredients or fillers harmful to human and animal life or plants.

4. Furnish a certificate of compliance stating that the materials used meets the Specifications when required by the Engineer.
5. Fertilizers for Soil Mixes:
 - a. Slow release compound fertilizer which shall be incorporated in soil mix at a rate of 300 g per tree/plant conforming to following.
 - N: 6.5 percent
 - P_2O_5 (soluble): 11.5 percent
 - P_2O_5 (insoluble): 33.2 percent
 - K_2O : 7 percent
 - Mg: 11.8 percent
 - b. Controlled release fertilizer shall be organic resin coated complete fertilizer with an analysis of 16-17-5+Fe and a release longevity of 12 - 14 months at 21°C soil temperature. Fertilizer planting tablets shall be tightly compressed fertilizer chips forming planting tablets and shall contain the following minimum percentages of plant food by weight:
 - Nitrogen: 12 - 20 percent
 - Phosphoric acid: 8 - 10 percent
 - Potash: 3 - 25 percent
 - c. Agricultural Grade Sulphur (S): 99 percent sulphur content with 100 percent passing a No. 16 mesh screen.
6. Fertilizer to be included, but not limited to, in the soil mix: Soil Sulphur, Superphosphate, Ammonium Sulphate.

2.02 LANDSCAPE PLANTING MATERIALS

A. General:

1. Landscape planting materials shall conform to the applicable standards and nomenclature of the American Standard for Nursery Stock and the Royal Horticultural Society Dictionary of Gardening.
2. Refer to the planting schedule and drawings for the complete list of planting materials.

B. Trees, Plants and Ground Covers:

1. Trees, plants, and ground covers shall be nursery grown in accordance with good horticultural practices, and grown under climatic conditions similar to those in the locality of the Project for at least 2 years.
2. Trees shall be typical of their species or variety, with normal growth,

- sound, healthy, vigorous, well-branched, and densely foliated. They shall be free of diseases, insect pests, eggs or larvae and shall have a well-developed root systems.
3. Trees shall have straight trunks with the leaders intact, undamaged and uncut. Old abrasions and cuts shall be completely calloused over.
 4. Standardized Plant Names: Names of the plants shown on the drawings conform with the names given in American Joint Committee on Horticultural Nomenclature (ACJHN) Latest Edition of Standardized Plant Names. Plant species not listed therein shall conform to plant names accepted in the trade and deliveries shall be accompanied by appropriate patent certification.
 5. Plants to be Furnished: Furnish plant material in accordance with that named on the Drawings. Replace plant material deviating from the correct plants at no additional cost. The Engineer reserves the right to inspect plants at place of growth, but such inspection shall not preclude the right of rejection of the planting site before and/or after planting.
 6. Quality and sizes: Furnish plants in conformance with the sizes required by the Drawings. The size of the plants measured before pruning shall conform to the measurements specified. Plants larger in size than those indicated may be furnished with the approval of the Engineer, but at no change to the contract price. For larger plants, the ball of earth or spread of roots shall be proportional to the size of the plant.
 7. Root Treatment: Immediately after digging, cover roots of bare root plants with a thick coating of mud or puddling, or wrap in a wet straw, moss, or other suitable packing material for protection until delivery.
 8. Containerized plant material shall have been growing in their containers for at least one year or sufficiently long enough to develop a root system capable of holding the soil intact after the removal from the container.
 9. Minimum Tree Ball Sizes And Shapes: Ball size shall be 300 mm diameter for each 25 mm of trunk diameter measured 300 mm above the ground line. Ball shapes shall be truncated cones; however, root growth structure of designated species and local soil conditions may require variation.
 10. Palms shall be of the size as stated on the Drawings and Schedules. Palms planted in a group or on road verges shall be approximately uniform in size unless stated otherwise. Trees shall have neatly trimmed trunks with no frond shrubs or fibrous matting.

11. Options: Plants may be furnished container grown instead of balled and burlaped or bare root, provided size requirements are met and the plant containers are proportional with sizes of plants to be furnished.
12. Substitutions: Plants or cultivars other than those named in the list of plants to be furnished will not be accepted unless specifically approved in writing by the Engineer.
13. Labels: Identify clearly shipments of plants. Durable and legible labels stating correct names and sizes of plants shall be securely attached to individual plants, bundles of like variety and size, as delivered to the site for inspection and planting identification.

C. Handling of Planting Materials:

1. Heavy balled plants shall be carefully handled to prevent cracked or broken plant balls.
2. No plant shall be handled by or lifted by the stem or foliage.
3. Handle plants in such a manner as to avoid damage and protect roots from drying at all times.
4. The ball of balled and burlapped plants which cannot be planted immediately upon delivery shall be covered with moist soil, mulch, or other covering to protect from drying, wind and sun. Plants shall be watered as necessary until planted.
5. Spray palms or other bare root or root balled plants with an acceptable trade anti-desiccant spray at the nursery or grove prior to shipping.

D. Shipping of Planting Materials:

1. Notify the Engineer in advance of the time and mode of shipping.
2. Furnish copies of the required custom documents to the Engineer 14 days prior to schedule shipment.
3. Plant materials shall be packed to provide adequate protection against climatic and physical injuries during transit. Plants shall be securely covered to prevent wind-whipping and drying.
4. Freight containers shall be carefully packed and adequately ventilated in accordance with the plant requirements to prevent sweating of the plants during transit. Shipments shall be given special attention to insure prompt delivery to job site.
5. Plants shall be treated with required pesticides just prior to shipment or as necessary to comply with local regulations.

6. The required inspection and transportation certificates will accompany each shipment.
- E. Delivery to the Planting Site:
1. Supplier shall notify the Engineer of the scheduled delivery dates 30 days prior to the shipping date. Send 2 copies of an itemized plant material list with the delivery notice to insure coordination of the required inspection at the point of delivery.
 2. Once delivered, plants shall be cared for and protected from damage and deterioration until they are planted at the locations shown on the drawings. All the palms, trees/shrubs and groundcover material shown on the drawings shall be stored and maintained at the Site Plant Nursery.
 3. Plants shall be properly acclimatized to the local site conditions.
- F. Inspection: Plant materials delivered to the planting site will be carefully inspected prior to acceptance for planting. Plants damaged by breakage and beyond the point of corrective pruning, or drying by heat, or not meeting the standard requirements and specified sizes, will not be accepted.
- G. As approved by the Engineer, construct a nursery and propagation unit at site for the acclimatization, propagation and storage of planting materials. Location and design shall be approved by the Engineer. Upon completion of Project, nursery facility shall be maintained for one year.

2.03 MISCELLANEOUS MATERIALS

- A. Tree Stakes: Provide tree stakes for supporting trees as shown on the Drawings.
- B. Tree Ties: Proprietary reinforced rubber or plastic, fully adjustable 600 x 25 mm clinch type tree ties or plastic buffer through which the tie passes between the tree and the stake.
- C. Guy wires and Turnbuckles: Galvanized woven drawn steel wire attached to galvanized turnbuckle assemblies.
- D. Guy Wire Covers: To protect the tree against abrasion of the guy wire, flexible reinforced rubber hose shall be threaded over the guy wire in the location where the wire loops around the tree trunk and branches only.
- E. Guy Wire Markers: Guy wire shall be covered in 15 mm Schedule 40 white PVC tubing up to 2 meters above ground level.
- F. Anti-Desiccant: Emulsion-type, film forming agent designed to permit plant transpiration, but retard excess loss of moisture. Apply according to the

manufacturer's instructions.

- G. Sub-Surface Drainage Gravel: Anti-capillary drainage layer shall be constructed of 12 - 20 mm nominal size angular gravel with no fines and shall have a minimum thickness of 150 mm.
- H. Gravel Mulch: Crushed limestone aggregate from off-site source, well graded, clean, free of organic materials, and screened 10 - 30 mm size.
- I. Filter Membrane: Spun-bonded polypropylene fabric manufactured by an integrated process of fiber spinning and bonding and conforming to the following requirements:
 - Weight: 136 g/m²
 - Thickness: 0.49 mm
 - Multi-Directional Test Strength: 100 N/m²
 - Elongation at Break: 32 percent
 - Pore Size: 120 micrometers
- J. Hessian: A coarsely woven mixture of hemp and jute, naturally biodegradable for wrapping palm tree fronds or other protection purposes.
- K. Irrigation Water: Water used for irrigation shall be analyzed by a registered institution and the report of which shall be approved by the Engineer. Report shall show conformance with the following standards:
 - Maximum total Dissolved Solids: 1,500 ppm
 - Electrical Conductivity: 1.8 milli-moh/cm
 - Maximum Ph: 8
 - Maximum Temperature: 30°C
 - Maximum Specific Intoxicity:
 - * Na: 200 ppm
 - * Cl: 350 ppm
 - * B: 0.75 ppm
 - * SO⁴: 750 ppm
- L. Insecticide and Fungicide: Use insecticide and fungicide if any disease occurs. Identify type of disease as well as the appropriate section of insecticide and fungicide which shall be delivered in the manufacturer's containers and shall be used according to insecticide manufacturer instructions. Materials used shall strictly comply with applicable laws governing their use.
- M. Tree Paint: Specifically formulated for the treatment of tree wounds or cut branches, and shall be free of chemicals which may burn the live tissue of the tree.

3. PART 3 - EXECUTION

3.01 SOIL MIXES

- A. General: The following soil mixes shall be used as appropriate.
1. Palm Tree Soil Mix: A two-part mix. Surround palm tree pruned root ball by red sand with no additives. This encasement in red sand only shall be the diameter of one and a half times the root ball in size. The rest of tree pit shall be filled with a soil mix similar in composition to that of trees, shrubs and ground cover.
 2. Trees/Shrubs/Ground Cover Soil Mix:
 - Agricultural Soil: 20 percent by volume
 - Red Sand: 60 percent by volume
 - Peat Moss: 20 percent by volume
 - Water Retaining Polymer: 2 Kg/m³
 - Fertilizer: As specified

3.02 SOIL PREPARATION

- A. Mix completely and compound the soil mix using approved mechanical methods before placement in tree pits, shrubs and ground cover beds.
- B. Add the approved fertilizers to the soil mix at a rate of 450 g/m³ unless otherwise recommended by the Engineer. Provide additional slow release fertilizer tablets for tree pits at a rate of 20 g per tree to be incorporated in the soil mix.
- C. Planting bed shall consist of a soil mix over sub-surface drainage of crushed aggregate or gravel which has been placed to the depth as shown on the drawings.
- D. Provide filter membrane where specified with 300 mm overlapping between the soil mix and the sub-surface drainage.
- E. Place soil mix in 150 mm lifts, wetted, tamped to fill to finish grade as shown on the drawings. After soil mix has been placed, rake to true lines, free from unsightly variations, bumps, ridges or depressions.
- F. Remove sticks, stones, roots and other objectionable materials from the soil which might interfere with formation of finely graded seed bed.
- G. No planting shall take place until the plant bed locations and lawn areas are approved by the Engineer.

3.03 INSTALLATION OF PLANTING MATERIALS

- A. Irrigation System: Utilize the installed automatic irrigation system and hoses from the quick couplers for the Project. Furnish water hoses and

other equipment required for watering the plants.

- B. Planting Season: Conduct planting operations under favorable weather conditions during the season which is normally accepted in the locality.
- C. Layout: Accomplish the ground layout for planting as approved by the Engineer prior to any planting, and following completion of planting soil installation. Stake location for individual plants, outline planting beds, and mark the location of plants within a planting bed other than ground cover.
- D. Planting Obstructions:
 - 1. Remove obstructions encountered excavation of planting pits, such as loose rocks, boulders, or construction debris. Existing underground utility lines, new or in use, shall not be disturbed.
 - 2. When such are encountered or other obstructions appear that are greater in diameter than the diameter of the planting pit being prepared, the position of the plant shall be shifted or relocated as determined by the Engineer.
 - 3. No explosives will be used for the removal of rock or other obstructions. Repair and/or replace damages to structures and/or utility lines at no additional cost.
- E. Excavation for Planting:
 - 1. Size planting pits for trees as detailed. Increase pits accordingly in size as required for larger trees.
 - 2. For bare root trees and shrubs, make excavations at least 300 mm wider than root spread and deep enough to allow for setting of roots on a layer of compacted backfill and with collars set at same grade as in nursery.
 - 3. For balled and burlaped trees and shrubs, make excavations at least half again as wide the ball diameter and equal to the ball depth, plus applicable allowance for setting of ball on a layer of compacted backfill.
 - 4. For container grown stock, excavate as specified for balled and burlaped stock, adjusted to size of container width and depth.
 - 5. Mechanical diggers may be used in the excavation of tree pits, however, the vertical sides of the pits, burnished to a hard smooth surface, shall be scarified and/or fractured to eliminate the impervious walls.
 - 6. Where substrate formation inhibit proper drainage, Provide trenches to prevent water collecting in tree pits.

F. Filter Membrane:

1. Install filter membrane directly above the drainage layer ensuring the membrane is laid out to minimize small filler pieces around the edges of the planting area. Membrane shall overlap 150 mm and shall be stapled or woven together at 300 mm intervals to ensure the membrane joint will not be moved during backfilling.
2. Wrap up the planting pit sides with membrane providing excess above finished grade during backfilling. Once backfilling has been completed and the finished soil levels achieved, trim the membrane neatly to the finished soil level.

G. Backfilling:

1. After backfilling plant pit approximately 60 percent full, in 150 mm lifts, add water and allow soil mix to settle. Add additional soil to finish grade.
2. After settlement, add additional planting mix required to bring pit to finish grade.
3. Removal of containers and/or severing of the sides of plantable containers shall be completed in a manner which will leave the balls of roots and soil intact. Handling methods which result in ball damage will be sufficient reason for rejection of the plant.

H. Setting Plants: Set plants in an approved topsoil in pits as shown on the Drawings. After initial watering and settlement, plants shall be at the same ground level grade as the relative grade of the ground from which they are dug. Set plumb upright growing trees and adjust shrubs and spreading type plants to produce their natural form and profile.

I. Balled and Container Grown Plants:

1. Place a minimum of 100 mm of compacted topsoil mixture in the bottom of the pit or to depth necessary to set the plant to required grade.
2. Place planting mixture around ball and carefully compacted to avoid injury to ball and to fill voids.
3. Cut and remove burlap, rope, wire or other wrapping materials away from the top of the ball and out of the pit. Do not remove burlap or ties from sides or bottom of ball.
4. Remove plastic materials from the pit.
5. Cut off broken or frayed roots cleanly and treat the areas cut with the approved tree paint.

- J. Bare Root Plants: Roots of bare root plants shall be spread out and carefully worked into root system. Broken or frayed roots shall be cut off prior to planting.
- K. Relocating Plants:
1. Prior to uplifting a palm to be relocated, prepare and approve the new location. This will involve placement of the soil mix and red sand in a pre-made hole, together with excavation and burial of the dead men or anchors with attached guy wires.
 2. Palms to be relocated should be temporarily guyed or propped to prevent collapse prior to excavation of the root ball.
 3. The leaf fronds shall be substantially reduced in number leaving only the 20 youngest ones closest to the growing point.
 4. Root ball shall be carefully and evenly excavated around the sides gradually working underneath the root ball to the center of the tree. Slings should be attached around the trunk of the tree and the weight taken up by the crane prior to the final excavation below the root ball.
 5. Once the root ball is free of the ground the crane shall lower the tree down to ground level, care being taken not to damage the foliage. Spray fronds with anti-desiccant spray to the quantities as in accordance with the manufacturer's recommendations and instructions. Tie up the fronds with hemp rope and the growing point wrapped in hessian from 1 m below the growing point to 1 m above. Tie up the trunk cutting back any untidy leaf midrib stalks ensuring the trunk is trimmed to an even state.
 6. Move the tree to its new location. Immediately prior to planting, the roots shall be inspected and cut back to the root ball leaving roots clean cut. Cut away rotting or diseased roots and treat with tree paint.
 7. Lift tree into position ensuring the root ball is planted 150 mm deeper than originally grown with reference to proposed finished grade then surround the root ball by red sand. Backfill the soil mix and the red sand to achieve finished grade.
 8. Install guy wires with wire markers, covers and turnbuckles, tighten and position the tree to a balanced and vertical position. Due to the growth habit of some of the larger palms to be relocated this may not be precisely vertical, however, the tree shall appear in a structurally correct orientation.
 9. For palm trees to be supplied from off-site location the orientation sequence shall be the same, however, the trunk trimming shall be

done by the Contractor and not by the supplier.

10. If palms have to be stored, this shall be for the shortest possible time during which they shall be kept in a shaded location with the root ball wrapped in hessian.

L. Trees:

1. Plant trees in pits of diameters as indicated on the Drawings. Use the specified soil mix as a backfill.
2. Water trees each day for the first 3 months.

M. Shrubs and Ground Covers:

1. Plant shrubs, and ground covers in a prepared soil mix bed, 450 mm deep for shrubs and 350 mm deep for ground covers.
2. Plant shrubs and ground covers after planting the trees. Space as shown on drawings, adjusting as necessary to evenly fill planting bed using specific quantity of plants.
3. Final grade of beds shall be 50 mm below walkways and curbs.
4. No plants shall be taken from the nursery for planting until after the pits or holes for the plants have been properly excavated, watered, and prepared to receive the plant material.

N. Watering and Adjusting:

1. Water plants thoroughly after setting. During and immediately after watering, adjust plants as necessary to ensure correct depth of planting, vertical alignment and/or natural profile.
2. Firm soil around each plant as final adjustments are made. Form the saucer required for holding mulch and water at this time.
3. Dispose excess soil resulting from planting excavation off the site or as directed by the Engineer.

O. Pruning, Staking and Guying:

1. Pruning: To be limited to the minimum. To be used for removing broken twigs and branches and to compensate for the loss of roots dying while transplanting. Paint cuts of 19 mm in diameter using an approved tree wound paint. Trimming performed in excess of, or contrary to, the requirements will not be acceptable, and the plant so pruned shall be replaced with a new one.

2. Staking and Guying: Set trees plumb and brace rigidly in position. Tamp soil mix solidly around ball prior to staking or guying. Complete Staking and guying operations immediately after planting. Perform work in the manner illustrated on Drawings. Care shall be taken to ensure that the stake does not rub against any part of the tree or penetrate root ball. Nail two galvanized clout nails to the stake to prevent slippage.
- P. Mulching: Place gravel mulch, of the required thickness, planted areas and where indicated.
- Q. Maintenance, Guarantee and Replacement:
1. Maintain landscape planting for one full calendar year after completion of the Project. Replace providing new materials similar in specifications to the damaged or dead plants or area of planting judged by the Engineer to be dead or damaged through lack of maintenance or otherwise unsatisfactory within this period at no additional cost to the Owner.
 2. Maintenance includes watering, weeding, mulching, cultivating, tightening or replacing stakes, firming in and pruning. Re-plant a minimum quantity of spare plant materials of all species specified in this Project. Occasional site visit of a horticultural specialist shall be the responsibility of the Contractor during the warranty period.
 3. Whenever possible, watering will be done at night to minimize evaporation and burning of plants. Do not over-water or allow water to fall on walks, streets, building or other structures.
 4. Supplemental Fertilizing: At bi-monthly intervals after planting (starting 1 month after planting), trees, shrubs, ground and covers shall receive supplementary fertilizer applied at the following rates:
 - Trees over 50 mm caliper: 45 g each
 - Trees under 50 mm caliper: 23 g each
 - Shrubs and Ground Covers: 23 g each
 5. Apply supplemental fertilizer at a distance not closer than 150 mm to trunks of trees or shrubs. Wash off immediately any fertilizer on the foliage of plants. Water fertilized areas in sufficient quantity to wet entire root structure of plants.
 6. Herbicides and Pesticides: If it proves necessary to use herbicides or pesticides, submit a schedule of materials to be used containing the constituent chemical, manufacturer application rate, application method and application interval to the Engineer for approval.
 7. Stake, Tree Tie and Hessian Removal: Prior to maintenance handover, inspect stakes, tree ties and hessian wrapping and remove materials that are no longer required to support healthy

plant growth.

Adjust or remove materials that are to be left in place as necessary to ensure proper plant growth.

8. Maintenance Handover: Contact the Engineer 45 days prior to the end of the maintenance period and provide the opportunity for the Owner's personnel to familiarize themselves with the landscaping maintenance work.
9. Submit monthly maintenance reports to the Engineer indicating nature and extent of maintenance work performed, including watering, cultivation, spraying and fertilizing, as well as plant losses and dates of replacement.

3.04 CLEAN-UP

- A. Upon the completion of construction, and before final acceptance, broom-clean hard surfaced areas within the contract limits. Remove tools, surplus materials, and equipment as well as debris and leave the site in a neat and acceptable condition meeting the approval of the Engineer.

END OF SECTION

SECTION 05500

METAL FABRICATIONS

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Metal fabrications of iron and steel shapes, plates, bars, strips, tubes, pipes and castings as well as other metal systems as indicated on Drawings and as specified in this section.
- B. Railings and handrails.
- C. Entry gates.
- D. Boundary fence.
- E. Aluminum Sheets for Facades Wall and Roof Cladding
- F. Aluminum Sheets Cladding for Entrance and Shade Steel Structure Canopy
- G. Aluminum Cladding for Columns
- H. Catwalk and Pipe Grids
- I. Louvers and Grilles
- J. Manhole covers and Frame
- K. Grating
- L. Metal Ladders.
- M. Access roof hatch.
- N. Access Doors and Panels.
- O. Concrete Steps and Loading Dock Nosing.
- P. Aluminum Shade Structure

1.02 FABRICATION

- A. Shop fabricate metal fabrication units as far as practicable. Use materials of the required size and thickness to produce adequate strength and durability in the finished product for the intended use. Work to the dimensions shown or accepted on shop Drawings using proven details of fabrication and support. Use the type of materials shown or specified for the various components of work.
- B. Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges.

- C. Ease exposed edges to a radius of approximately 1 mm unless otherwise shown.

1.03 REFERENCES

B. AAMA - American Architectural Manufacturer Association

AMMA 603.8	Pigmented Organic Coating on Extruded Aluminum.
AMMA 605.2	High Performance Organic Coatings on Architectural Extrusions and Panels
AAMA 606.1	Color Anodic Finishes for Architectural Aluminum
AAMA 607.1	Clear Anodic Finishes for Architectural Aluminum

C. ANSI - American National Standards Institute:

ANSI A 14.3	Safety requirements for Fixed ladders
ANSI A 202	Metal Bar Grating Manual

D. ASTM - American Society for Testing and Materials

ASTM A 27	Steel Castings, Carbon, for General Application
ASTM A 36	Structural Steel
ASTM A 48	Gray Iron Castings
ASTM A 53	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A 123	Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 307	Carbon Steel Externally Threaded Standard Fasteners
ASTM A 325	High Strength Bolts for Structural Steel Joints
ASTM A 446	Steel Sheet, Zinc Coated (Galvanized) by the Hot-Dip Process, Structural (Physical) Quality
ASTM A 500	Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A 501	Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
ASTM A 526	Steel Sheet, Zinc Coated (Galvanized) by the Hot-Dip Process, Commercial Quality
ASTM B 209	Aluminum and Aluminum-Alloy Sheet and Plate

ASTM B 221 Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes and Tubes

E. AWS - American Welding Society

AWS-B3.0 Welding Procedure and Performance Qualification

AWS-D1.1 Structural Welding Code-Steel

F. SSPC - Steel Structures Painting Council

SP-10 Near-White Blast Cleaning

PS-12.00 Guide for Selecting Zinc-Rich Painting Systems

1.04 SUBMITTALS

- A. Product Data: Submit Manufacturer's product information, specifications and installation instructions for the miscellaneous metal fabrications.
- B. Shop Drawings: Submit complete shop drawings, including details of fabrication, assembly and erection of each metal fabrication indicated. Include plans, elevations, sections, and details of metal fabrications and connections. Show anchorage and accessory items.
- C. Samples: Submit samples of representative materials, finishes and finished products as required by the Engineer. Samples shall be full size, taken from Manufacturer's stock and complete as required for installation.

1.05 TRANSPORTATION, HANDLING AND STORAGE

- A. Crate and pack material as required to prevent damage, corrosion and other forms of deterioration. Stack material out of mud and dirt and provide for proper drainage. Exercise care to avoid abrasions and other damage to finish coating. Protect from damage or soiling by adjacent construction operations. Keep material off ground by using pallets, platforms, or other supports. Protect material against corrosion and deterioration.

1.06 QUALITY ASSURANCE

- A. Field Measurements: Take field measurements prior to preparation of shop drawings and fabrication, to ensure proper fitting of the work. Coordinate fabrication schedule with construction progress to avoid delay of work.
- B. Shop Assembly: Preassemble items in the shop to greatest extent possible, so as to minimize field splicing and assembly of units at site.
- C. Fabricator's Qualifications: A firm having a minimum of 5 years successful experience in producing metal fabrications similar to that required for this Project. The fabricator shall be subject to approval of the Engineer.
- D. Installer's Qualifications: A firm having a minimum of 5 years successful experience in the installation of metal fabrications similar to that required for this project, and that has been licensed by the Manufacturer of the metal

fabrications. The installer shall be subject to approval of the Engineer.

- E. Welding Work: Comply with the requirements of American Welding Society (AWS) - **Standard Code for Arc and Gas Welding in Building Construction** as well as AWS D1.1 - **Structural Welding Code** for welding procedures. Welders shall be subject to approval of the Engineer.

PART 2 - PRODUCTS

2.01 MATERIALS

- F. General: Material shall conform to the requirements specified for the particular item(s), and where these requirements are not specified in detail, the material shall be suitable for the intended use, and as approved by the Engineer.
- G. Metal Surfaces: For fabrication of miscellaneous metal work which shall be exposed to view, materials shall be smooth and free of surface blemishes such as pittings, seam marks, roller marks, rolled trade names, and roughness.
- H. Structural steel shapes, plates and bars: Conform to ASTM A 36 or A 529.
- I. Steel Plates to be Bent or Cold-Formed: Conform to ASTM A 283, Grade C.
- J. Steel Bars for Grating: Conform to ASTM A 569 or ASTM A 36.
- K. Cold-Formed Steel Tubing: Conform to the requirements of ASTM A 500, Grade B.
- L. Hot-Formed Steel Tubing: Conform to the requirements of ASTM A 501.
- M. Steel Pipe: Conform to the requirements of ASTM A 53, Type E or S, Grade B; or ASTM A 501.
- N. Members Fabricated by Cold Forming: Conform to requirements of ASTM A 607, Grade 50.
- O. Galvanized Cold-Formed Members: Conform to requirements of ASTM A 446, Grade D; galvanized to ASTM A 525 Designation G-90.
- P. Steel Casting: Conform to requirements of ASTM A 27, Grade 65-35, medium-strength carbon steel.
- Q. Gray Iron Castings: Conform to ASTM A 48, Class 30.
- R. Malleable Iron Castings: Conform to ASTM A 47.
- S. Cold-Rolled Carbon Steel Sheets: Conform to ASTM A 366.
- T. Galvanized Steel Sheet: Conform to the requirements of ASTM A 446 Grade C, galvanized to ASTM A 525, Designation G-90.
- U. Bolts for Structural framing: High strength bolts shall be heavy duty hexagonal structural bolts with heavy duty hexagonal nuts conforming to ASTM A 307, A 325 or A 490 as necessary for design loads and connection details.

- V. Concrete Inserts: Threaded or wedge type, galvanized ferrous castings, either malleable iron, ASTM A 47, or cast steel, ASTM A 27. Bolts, washers and shims shall be hot-dip galvanized, ASTM A 153.
- W. Anchor Bolts: Conform to ASTM A 307.
- X. Structural Steel Primer Paint: SSPC-Paint 2, red lead iron oxide, oil alkyd.
- Y. Finish Paint: Refer to Section 09900 - PAINTING.
- Z. Non-Shrink Grout: Premixed, non-corrosive, non-staining, non-gaseous, ready to use natural aggregate product requiring only the addition of water to produce flowable grout material having no drying shrinkage or settlement at any age. Compressive strength (50 mm cube) shall not be less than 500 kg/cm² at 28 days.
- AA. Aluminum Extruded Bars, Rods, Shapes and Tubes: Conform to ASTM B 221, 6063-T6; aluminum sheets and plates to ASTM B 209, alloy 5052-H32; structural pipes and tubes (extruded) to ASTM B 429.
- BB. Stainless Steel:
 - 1. Bar stock: Conform to ASTM A 276, Type 304.
 - 2. Plates and Sheets: Conform to ASTM A 167, Type 304.
 - 3. Pipes: Conform to ASTM A 312, Type 304.
- CC. Copper Alloys, Brass:
 - 1. Extruded Shapes: ASTM B 249, alloy UNS No. C36000 (free-cutting brass).
 - 2. Seamless Tube: ASTM B 135, alloy UNS No. C26000 (cartridge brass, 70 percent copper).
 - 3. Sand Castings: ASTM B 584, alloy UNS No. C85200 (high copper yellow brass).
 - 4. Plates and Bars: ASTM B 36, alloy UNS No. C26000 (cartridge brass, 70 percent copper).
- DD. Copper Alloys, Bronze:
 - 1. Extruded Shapes: ASTM B 455, alloy UNS No. C38500 (architectural bronze).
 - 2. Seamless Pipe: ASTM B 43, alloy UNS No. C23000 (red brass, 85 percent copper).
 - 3. Seamless Tube: ASTM B 135, alloy UNS No. C23000 (red brass, 85 percent copper).
 - 4. Composition Bronze castings: ASTM B 62, alloy UNS No. C83600 (85-5-5-

5 or No.1 composition commercial red brass).

5. Sand Castings: ASTM B 584, alloy UNS No. C86500 (No. 1 manganese bronze).
6. Plates and Bars: ASTM B 36, alloy UNS No. C28000 (Muntz metal, 60 percent copper).

EE. Fasteners:

1. General: Provide zinc-coated fasteners for exterior use or where built into exterior walls. Select the fasteners for the type, grade and class required.
2. Bolts and Nuts: Regular hexagonal head type, conforming to ASTM A 307, Grade A.
3. Lag Bolts: Squared head type.
4. Machine Screws: Cadmium plated steel.
5. Wood Screws: Flat head carbon steel.
6. Plain Washers: Round carbon steel.
7. Masonry Anchorage Devices: Expansion shields.
8. Toggle Bolts: Tumble-wing type.
9. Lock Washers: Helical spring type carbon steel.
10. Power Actuated Fasteners:
 - a. Provide fasteners of special spring steel alloy conforming to ASTM A 227, Class 1 with a hardness of 52 - 56 Rockwell C, zinc-plated meeting ASTM A 164, Type RS.
 - b. Drive pin or threaded stud types as required.

2.02 FABRICATED ITEMS

- A General: Use materials of size and thickness indicated on Drawings. Where not indicated, use sizes and thickness required to achieve strength and durability in finished product. Work to the dimensions indicated or approved on shop drawings, using proven details of fabrication and support. Fabrication shall be done in shop to fullest extent as possible with only assembly and installation works to be done on site.
- A. Form exposed work to the lines and levels with accurate angles and surfaces and straight sharp edges. Form the bent-metal corners to the smallest radius possible without causing grain separation or otherwise impairing work.
- B. Railings and Handrails: Fabricate railings and handrails assemblies which when installed shall be capable of withstanding a concentrated load of 0.9 kN (200 lbf) applied at any point in any direction, and uniform load of 0.73 kN/m (50 lbf/ft) applied simultaneously in both vertical and horizontal directions.

1. Stainless Steel Handrail and Railing with Glass Railing for Atrium and Stairs:
 - a. Construction: Manufacturer's standard stainless steel handrail and railing conforming to the following:
 - (1) Tubing: ASTM A 554 GRADE MT 304.
 - (2) Pipe: ASTM A 312, grade TP 304.
 - (3) Castings: ASTM 743, grade CF 8 or CF 20.
 - (4) Plate: ASTM A 167, type 304.
 - b. Size and Shape: As indicated on Drawings.
 - c. Finish: As indicated on Drawings and in accordance with the following:
 - (1) Satin, Directional Polish: AISI No. 6 finish.
 - d. Glass Railing System:
 - (1) Construction: Glass railing panels shall be fitted into horizontal railing moldings strips supported to vertical stainless steel supports as shown in Drawings.
 - (2) Mounting: as shown on Drawings.
 - (3) Glass for the Railing: Clear tempered glass conforming to safety requirements of. Size and thickness of glass panels shall be as recommended by the manufacturer, unless indicated otherwise on Drawings. Glass shall also comply with requirement of Section 08800 - GLAZING.
 - e. Miscellaneous Materials:
 - (1) Handrail Accessories: Provide elbows and bends as well as end caps for the handrail using same material and finish as that of the handrail specified herein.
 - (2) Fittings: Fittings shall be concealed and fabricated of stainless steel. Exposed fittings, when approved by the Engineer, shall have a finish similar to that of the adjacent components.
 - (3) Mechanical Fasteners: Stainless steel or cadmium-plated steel as recommended by the Manufacturer.
2. Stainless steel piping railing and handrail:
 - a. Stainless steel pipe handrail and railings shall be fabricated from stainless steel pipe, conforming to ASTM A 312, Type 304 and shall be as recommended by the manufacturer to conform with the structural performance. Design, shape and dimensions of handrail and railing

shall be as indicated on Drawings. Submit shop drawings showing design shapes and fixing details for the Engineer's approval.

- b. Finish: Stainless steel pipe railing and handrail shall have finish No.6 satin finish or as approved by the Engineer.
3. Stainless steel piping handrail and wall bracket railings:
 - a. Stainless steel pipe handrail and wall bracket railings shall be fabricated from Stainless steel pipe handrail and wall bracket shapes railings, conforming to ASTM A 312, Type 304 and shall be as recommended by the manufacturer to conform with the structural performance. Design, shape and dimensions of handrail and wall bracket railing shall be as indicated on Drawings. Submit shop drawings showing design shapes and fixing details for the Engineer's approval.
 - b. Finish: Stainless steel pipe railing and wall bracket handrail shall have finish No.6 satin finish or as approved by the Engineer..
4. Galvanized steel piping railing and handrail:
 - a. Steel pipe handrail and railings shall be fabricated from galvanized steel pipe, cold formed, conforming to ASTM A 500, grade 40 or shall be as recommended by the manufacturer to conform with the structural performance. Design of handrail and railing shall be as indicated on Drawings.
 - b. Finish: Steel pipe railing and handrail shall have a painted finish in accordance with Section 09900 - PAINTING. Color shall be as approved by the Engineer.
5. Galvanized steel piping handrail and wall bracket railings:
 - a. Steel pipe handrail and wall bracket railings shall be fabricated from galvanized steel pipe handrail and wall bracket shapes railings, cold formed, conforming to ASTM A 500, grade 40 or shall be as recommended by the manufacturer to conform with the structural performance. Design of handrail and railing shall be as indicated on Drawings.
 - b. Finish: Railing and handrail shall have a painted finish in accordance with Section 09900 - PAINTING. Color shall be as approved by the Engineer.

C. Entry Gates:

1. Gates:
 - a. Galvanized Steel Gates: Fabricate entry gates, vehicular and pedestrian, using galvanized steel, tubular sections and shapes conforming to ASTM A 36, hot-dip galvanized in accordance with ASTM A 123, coat designation G-90. Pedestrian gate shall be manually operated. Vehicular gates shall be electrically operated.

2. Shapes and Size: As shown on Drawings.
 3. Fabrication:
 - a. Fabricate gates in accordance with approved shop drawings. Submit various decorative designs for the Engineer's selection and approval.
 - b. Hardware: Provide complete heavy duty masonry hinges, gate latches, wheels, guide rail, locking devices, decorative latch assembly, and control system as recommended by the manufacturer.
 4. Vehicular Gate Operators:
 - a. Provide an electrically operated gate opener and control consisting basically of a hydraulic arm and hydraulic power unit connected to each other by two pipes. Arm is laid underground at the foot of gate and protected by a steel case treated against corrosion by a hot galvanized treatment. Upper cover shall be stainless steel. Operator shall have quick release knob for manual operation of gates during power failure.
 - b. Equipment shall be able to support weight of gate. Provide rise pump unit with hydraulic locking device and electrical lock to keep gates locked shut.
 - c. Installation: Gate operating system shall be installed by manufacturer's authorized workmen experienced in the trade. Installation of system shall conform to manufacturer's written instructions and approved drawings.
 - d. Warranty: Gate operating system shall be warranted against defects for one year from the date of substantial handover.
 5. Finish: Gates shall have a painted finish in accordance with Section 09900 - PAINTING. Color shall be as selected by the Engineer.
- D. Perimeter Fence:
1. Fences Types:
 - a. Galvanized Steel Sections Fence: Fabricate perimeter steel fence using galvanized steel, tubular sections and shapes conforming to ASTM A 36, hot-dip galvanized in accordance with ASTM A 123, coat designation G-90.
 2. Shapes and Size: As shown on Drawings. If required, submit various decorative designs for the Engineer's selection and approval.
 3. Finish: Fence shall have a painted finish in accordance with Section 09900 - PAINTING. Color shall be as selected by the Engineer.
- F. Aluminum Sheets for Facades Wall and Roof Cladding :
1. Wall and Roof Metal Suspension Structure: Metal structure for wall cladding

shall be manufactured of continuous vertical aluminium supporting sections fixed to walls by with stainless steel clip fixing anchors as shown on Drawings. Dimensions and shapes shall be as per manufacturer recommendations and the Engineer approval. Metal structure dimensions and shapes for roof cladding shall be as shown on Drawings and as per manufacturer recommendations and the Engineer approval.

2. Aluminum Sheet Cladding: Aluminum sheet cladding shall be manufactured as required of Aluminum sheets manufactured of two Aluminum sheets pressed on a thermoplastic layer with total thickness 4 mm. Insulation material shall be placed on back of cladding. Fasteners for fixing sheet on suspension metal structure shall be concealed and of same metal or of suitable materials as per manufacturer recommendations and the Engineer approval. All other fittings and fasteners shall be aluminum or stainless steel. Aluminum sheet cladding colors, shapes, dimensions and textures shall be as shown on drawings and as approved by the Engineer.

G. Aluminum Sheets Cladding for Entrance and Shade Steel Structure Canopy:

1. Metal Suspension Structure: Entrance and shade steel structure canopy shall be constructed of structural steel shapes, plates and bars and shall comply to ASTM A36 or A529. Steel Structure canopy shall comply with the requirements Section 05120 – STRUCTURAL STEEL. Size and shape shall be as shown on drawings and as per manufacturer recommendations and the Engineer approval.
2. Aluminum Sheet Cladding for Entrance and Shade Steel Structure Canopy: Aluminum cladding for entrance and shade steel structure canopy shall be of aluminum sheets manufactured of two Aluminum sheets pressed on a thermoplastic layer with total thickness 4 mm. Fasteners for fixing sheet on suspension metal structure shall be concealed and of same metal or of suitable materials as per manufacturer recommendations and the Engineer approval. All other fittings and fasteners shall be aluminum or stainless steel. Aluminum Cladding Sheet colors, shapes, dimensions and textures shall be as shown on drawings and as approved by the Engineer.

- H. Aluminum Cladding for Columns: Aluminum cladding for columns Shall be a custom formed shape from aluminum sheets manufactured of two Aluminum sheets pressed on a thermoplastic layer with total thickness 4 mm and concealed fasteners from same metal. All other concealed accessories shall be of aluminum or stainless steel. Column cladding shall be with butt joints as shown on Drawings. Sizes and shape shall be as shown on Drawings. Aluminum finish shall have the manufacturer's standard finish selected by the Engineer. Submit shop drawings showing design shape and fixing details for the Engineer's approval.

- I. Catwalk and Pipe Grids: Shall be fabricated of structure steel conforming to ASTM standards and as recommended by fabricator for type of use indicated to withstand design structural loads. Design, shape and size shall be as shown on drawings or as approved by the Engineer. Submit shop drawings showing structural design, shapes and fixing details for the Engineer's approval. Materials and finishes shall comply with the following standards

1. Suspension Members, Beams, Joists, Balusters, Railing

and Framing: Structural Steel, ASTM A 36.

2. Floor Grating: Steel bars for grating shall conform to ASTM A 569 or ASTM A 36. Rods for grating crossbars shall be ASTM A 510.
3. Floor Plates: Galvanized steel checkered plates conforming to ASTM A446 Grade C with a minimum thickness of 6 mm.
4. Grid Pipes: Shall be fabricated of hot-dipped seamless galvanized steel pipe, cold formed, conforming to ASTM A 500, size and shape as shown on drawings.
5. Welding: Conform to requirements of ANSI/AWS-D1.1 – continuous type welding.
6. Finish for Catwalk: Galvanized exposed finish.

J. Louvers and Grilles:

1. Louvers and frames: Provide manufacturer's standard aluminum louvers suitable for the application indicated on Drawings:
 - a. Fabricated Metal: Formed metal stationary louvers and frames, 12 gauge (2.80 mm thick). Provide stiffening members where required.
 - b. Fasteners and Anchors: Galvanized steel type.
 - c. Hardware: Provide all hardware complying with requirements of Section 08710 – FINISH HARDWARE.
 - d. Bird Screen (where required): 12.7 mm mesh x 1.60 mm diameter galvanized steel in folded frame.
2. Grilles (where required): Provide manufacturer standard decorative aluminum grilles suitable for the application indicated on Drawings and in accordance with the requirement specified herein.
3. Design and Fabrication: Submit various decorative designs for the Engineer's selection and approval. Fabricate louver and grille screen elements in accordance with approved shop drawings. Submit shop drawings showing design pattern and fixing details for the Engineer's approval. Provide bird screen and insect screen as indicated on Drawings.
4. Finish: Provide manufacturer standard finish as indicated on Drawings and in accordance with the following:
 - a. Powder-Coated Finish: Standard finish of thickness range 60 - 80 microns.
 - b. Color shall be as approved by the Engineer from standard color charts.

K. Manhole Covers and Frame: Gray cast iron casting, complying with ASTM A 48 or BS 497; Appendix A. Heavy duty and medium duty, Sizes shall be as shown

on Drawings.

L. Grating:

1. Stainless Steel Grating: Grating and frames shall be of heavy duty stainless steel, complying with the requirements of ASTM A 276, ASTM A 167 and ASTM A 312, Type 304. Size shall be as shown on Drawings.
2. Cast-Iron Grating and Trench Covers: Grating shall be of gray cast iron casting, heavy duty, complying with the requirements of ASTM A 48 or BS 497; Appendix A. Frames shall be steel. Size shall be as shown on Drawings.

M. Metal Ladders:

1. Fabricate and install ladders for locations shown on Drawings with dimensions, shape, details and anchorage as shown on Drawings and approved by the Engineer.
 - a. Galvanized Steel Ladders: Galvanized steel parts conforming to ASTM A 525, Designation G-90, including rungs, brackets, railings and fasteners. Rungs shall be 20 mm diameter solid structure steel bar spaced at 300 mm centers. Provide continuous side railing flat bar 50x10 mm ended with galvanized steel pipes 30 mm diameter as shown on Drawings. Provide non-slip surface on top of each rung as recommended by manufacturer and approved by the Engineer.

N. Access Roof Hatch:

1. Manufacturer's standard single leaf roof hatch to fit the opening as indicated on Drawings, complete with curbs, anchorage system, gaskets, roof flashing and other accessories required for a complete installation.
2. Door and curbs shall be of steel sheets (sandwich panel) with not less than 25 mm thick rigid polyurethane insulation. Roof hatch shall be provided with manufacturer's standard hardware including safety post.

O. Access Doors and Panels: Provide access doors and panels where required, of material, size and shape as shown on the Drawings.

P. Concrete Steps and Loading Dock Nosing: Concrete steps and loading dock nosing shall be of cast iron. Size, shape and details shall be as shown on Drawings

Q. Aluminum Shade Structure:

1. Aluminum shade structure shall be constructed of structural aluminum sections, shapes, plates and bars conforming to ASTM B 221, 6063-T6, for aluminum extruded bars, rods, shapes and Tubes and conforming to ASTM B 209, alloy 5052-H32 for aluminum sheets and plates and conforming to ASTM B 429 for structural pipes and tubes (extruded). Size and shape shall be as shown on drawings. Aluminum shade structure shall be constructed of aluminum structure covered with polycarbonate shade cover units of sizes and shapes as shown on drawings. Aluminum shade structure shall be supported on concrete structure as shown on drawings.

Fixing mechanical fasteners shall be stainless steel or cadmium-plated steel as recommended by the Manufacturer. Submit detailed design shop Drawings as per approved manufactured recommendations for the Engineer approval.

- a. Aluminum shade structure finish shall be anodized finish conform to AA C22A42; 22 micron thick; with shop-applied protective coating of clear acrylic lacquer or any coating in accordance with AAMA 602.2, 0.5 mil dry film thickness, over. Color shall be as approved by the Engineer.
 - b. Concrete Structure: Concrete, formwork and reinforcement for concrete structure shall comply with the requirements Division 3 - CONCRETE.
2. polycarbonate shade cover units: Polycarbonate glazing, thermoformable, extruded monolithic sheets, UV resistant, rated per UL 972, and with average impact strength of 638 to 850 J/m of width when tested per ASTM D 256, Test Method A (Izod). Provide glazed plastic sheet with thickness required for 1.9 kPa positive (external) loading and 0.95 kPa negative or uplift (internal) loading as recommended by skylight manufacturer for unit size and shape. Glazing gasket shall be Manufacturer standard glazing system of EPDM or neoprene gasket.

2.04 FABRICATION

- A. Shop fabricate metal fabrication units as far as practicable. Use materials of the required size and thickness to produce adequate strength and durability in the finished product for the intended use. Work to the dimensions shown or accepted on shop Drawings using proven details of fabrication and support. Use the type of materials shown or specified for the various components of work.
- B. Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges.
- C. Ease exposed edges to a radius of approximately 1 mm unless otherwise shown.
- D. Form bent-metal corners to the smallest radius possible without causing grain separation or otherwise impairing the work.
- E. Weld corners and seam continuously and in accordance with the recommendations of AWS. At exposed connections, grind exposed welds smooth and flush to match and blend with adjoining surfaces.
- F. Form exposed connections with hairline joints which are flush and smooth, using concealed fasteners wherever possible. Use exposed fasteners of the type shown or, if not shown, use flathead screws or bolts.
- G. Provide for anchorage of the type shown, coordinated with the supporting structure and the progress schedule. Fabricate and space anchoring devices to provide adequate support for the intended use of the work.
- H. Cut, reinforce, drill and tap metal fabrications indicated to receive finish hardware and similar items of work.

1. Exposed fastenings: Compatible materials, generally matching in color and finish, and shall harmonize with the material to which fastenings are applied.
 2. Provide the necessary rebates, lugs and brackets to assemble the work in a neat and substantial manner. Turn edges of flanged items to form plaster keys where plaster occurs. Drill and/or punch holes for bolts and screws. Conceal fastening where practical.
 3. Provide thickness of metal and details of assembly or supports to give ample strength and stiffness. Form joints exposed to weather in a way to exclude water.
 4. Where dissimilar metals are in contact, or where aluminum is in contact with concrete, mortar, masonry, wet or pressure-treated wood or absorptive materials subject to wetting, protect the surfaces with a coat of bituminous paint, unless otherwise specified, to prevent galvanic or corrosive action.
- I. Galvanizing: Provide a zinc coating for those items shown on the Drawings and specified to be galvanized using the hot-dip process after fabrication in accordance with the following:
1. ASTM A 153 for galvanizing of iron and steel hardware.
 2. ASTM A 123 for galvanizing of rolled, pressed and forged steel shapes, plates, bars and strip, 3 mm thick and heavier.
 3. ASTM A 386 for galvanizing of assembled steel products.
- J. Shop Prime Painting:
1. Shop prime paint metal fabrications, except those members or portions of members to be embedded in concrete or masonry, surfaces and edges to be field welded and galvanized surfaces, unless otherwise indicated.
 2. Remove scale, rust and other deleterious materials before the shop coat of paint is applied. Clean off heavy rust and loose mill scale in accordance with SSPC SP-2 Hand Tool Cleaning, or SSPC SP-3 Power Tool Cleaning or SSPC SP-6 Commercial Blast Cleaning. Remove oil, grease and similar contaminants in accordance with SSPC SP-1 Solvent Cleaning.
 3. Immediately after surface preparation, brush or spray on primer in accordance with the paint manufacturer's instructions, at a rate to provide a uniform dry film thickness of 0.05 mm for each coat. Use painting methods resulting in full coverage of joints, corners, edges and all exposed surfaces.
 4. Apply one shop prime coat to fabricated metal items, except apply two coats of paint to surfaces not accessible after erection. Change color of second coat to distinguish it from the first.

PART 3 - EXECUTION

3.01 INSPECTION

- K. Examine the areas and conditions under which metal fabrication items are to be installed. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Coordinate setting Drawings, diagrams, templates, instructions and directions for installation of anchorage such as concrete inserts, anchor bolts and miscellaneous items having integral anchors which are to be embedded in concrete or masonry construction. Coordinate the delivery of such items to the affected trades for installation.
- B. Take field measurements prior to fabrication and delivery of metal fabrications to ensure proper fit of work.
- C. Apply bituminous mastic coating to concealed surfaces of metal fabrications where metal will be in contact with dissimilar material, set in concrete or masonry, and potentially damp conditions to prevent corrosion of metal.

3.03 INSTALLATION

- A. Install units to allow for expansion and contraction from a minimum ambient temperature range of 0 - 49 degree C without causing deformation of units and over-stress of welds and fasteners.
- B. Set metal fabrications accurately in locations, alignments and elevations shown, plumb, level, true and free of rack, measured from established lines and levels.
- C. Fastening to In-place Construction: Provide anchorage devices and fasteners where necessary for securing metal fabrication items to in-place construction including threaded fasteners for concrete and masonry inserts, toggle bolts, through-bolts, wood screws and other connectors as required.
- D. Provide temporary bracing or anchors in formwork for items which are to be built into concrete, masonry or similar construction.
- E. Cutting and Fitting:
 - 5. Perform cutting, drilling, welding and fitting required for the installation of the metal fabrications.
 - 6. Fit exposed connections accurately together to form tight hairline joints. Weld connections which are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Grind joints smooth and touch-up shop paint coats.
 - 7. Do not weld, cut or abrade exposed surfaces which cannot be completely restored in the field.
 - 8. Drill holes for bolts and screws. Conceal fasteners where possible. Mill exposed ends and edges smooth, with corners slightly rounded.

- F. Field Welding: Conform to AWS Code for procedures of manual shielded metal-arc welding, appearance and quality of welds made and methods used in correcting welding work.
- G. Soldering: Conform to the recommendations of AWS Welding Handbook, Volume 2, Chapter 12 - Soldering. Use only for filling or sealing joints and not for mechanical strength. Where exposed to view, soldered joints shall be finished to match adjoining finish metal and made as unnoticeable as practicable.

3.04 PAINTING

- A. Touch-up Painting: Immediately after erection, clean field welds, bolted connections and abraded areas in shop applied paint. Paint damaged areas with the same paint used for shop prime painting. Apply by brush or spray to provide a minimum dry film thickness conforming to that specified in Section 09900 - Painting.
- B. Finish Painting: Painting of unfinished and prime coated metal fabrications required to be field painted shall conform to Section 09900 - PAINTING.

END OF SECTION

SECTION 05810

EXPANSION JOINT COVER ASSEMBLIES

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Pre-fabricated expansion joint cover assemblies as indicated on Drawings and as specified in this section.

1.02 REFERENCES

B. UL - Underwriters Laboratory

UL 263 Fire Test of Building Construction and Materials

C. ASTM - American Society for Testing and Materials

ASTM A 167 Standard Specification for Stainless and Heat-Resisting
Chrome-Nickel Steel Plate, Sheet and Strip

ASTM B 209 Standard Specification for Aluminum and Aluminum- Alloy
sheet and plate

ASTM B 221 Standard Specification for Aluminum and Aluminum- Alloy
extruded Bars, Rods, Wire, Shapes and Tubes

ASTM B 455 Standard Specification for Copper-Zinc Lead Alloy (Leaded-
Brass) Extruded Shapes

ASTM C 920 Standard Specification for Elastomeric Joint Sealants

ASTM E 119 Method for Fire Tests of Building Construction and Materials

ASTM E 814 Method for Fire Tests of Through Penetration Fire stops

D. AA - Aluminum Association

AA Designation System for Aluminum Finishes

E. AAMA - American Architectural Manufacturer Association

AAMA 603.8 Pigmented Organic Coating on Extruded Aluminum

AAMA 605.2 High Performance Organic Coatings on Architectural Extrusions
and Panels

AAMA 606.1 Color Anodic Finishes for Architectural Aluminum

AAMA 607.1 Clear Anodic Finishes for Architectural Aluminum

1.03 SUBMITTALS

- A. Product Data: Submit Manufacturer's product data on expansion joint cover assemblies.
- B. Samples: Submit samples of the metal finish not less than 150 mm long. Samples will be reviewed by The Engineer for color and texture only.
- C. Shop Drawings: Submit shop drawings showing configuration as well as extent of each type of unit and relationship to adjacent materials.

1.04 TRANSPORTATION, HANDLING AND STORAGE

- A. Deliver material to the site in packages or containers; labeled for identification with the Manufacturer's name, brand and contents. Store material in weather tight and dry storage facility. Protect from damage from handling, weather and construction operations before, during and after installation.

1.05 WARRANTY

- A. Submit 2 copies of written guarantee signed by the Manufacturer, and the Installer, agreeing to replace units which fail in material or workmanship within 2 years of date of handing over.

PART 2 - PRODUCTS

2.01 MISCELLANEOUS METALS

- B. General: Provide miscellaneous metal items and systems complete including incidental plates, angles, bolts, anchors and similar items, and welding required to join items and systems together and to other materials.
- C. Materials: Miscellaneous metal, unless otherwise indicated or specified, shall be mild steel conforming to ASTM A 7 for structural steel, and ASTM A 27 for cast steel.
- D. Aluminum: 6063-T5 Alloy, C1-R1-204 clear and anodized.
- E. Accessories: Manufacturer's standard anchors, fasteners, set screws, spacers, flexible seal and filler materials, adhesive and other accessories compatible with materials in contact, as shown or required for the complete installation.
- F. Wearing Surfaces: Manufacturer's standard, of the type as recommended for use.
- G. Protection: Cover exposed metal surfaces with the factory-applied adhesive paper or polyvinyl chloride (PVC) protective strip-coating.

2.02 PREMOLDED EXPANSION JOINT COVERS

- A. Where required, provide manufacturer's standard premolded expansion joint covers to suit the conditions as indicated on the Drawings.
- B. Where required, provide manufacturer's standard UL listed fire rated expansion

joint cover assemblies.

1. Fire rating of joint shall be as indicated on Drawings.
2. Achieve the required fire rating by using manufacturer standard methods and UL approved construction details.

2.03 FABRICATION

- A. General: Provide the basic profile and operating units for expansion joint covers as shown on Drawings. Select units comparable to those shown or required for the joint size and to absorb variations in adjacent surfaces and structural movement. Provide the longest practicable lengths to minimize the number of end joints. Provide hairline metered corners where joint changes direction or abuts other material systems.
- B. Wall Joint Cover Assemblies:
 1. Provide concealed, continuously anchored members fastened to wall only on one side of the joint. Extend cover to lap each side of joint with free movement. Attach cover to the anchor member with the cover in close contact with adjacent contact surfaces.
 2. Provide flexible vinyl moisture seal on slippage side under exterior covers and elsewhere as shown. Make other provisions as necessary to provide a weather tight installation.
- C. Floor Joint Cover Assemblies:
 1. Provide continuous angle shape seating members with raised floor rim and concealed bolt or stud anchors for casting into concrete.
 2. Provide one on each side of flat joints; one only on floor side of corner joints.
 3. Provide recessed cover plates for flat joints to receive floor covering and angle pattern cover plates for corner joints, unless otherwise shown. Lap sliding angles of cover plates on seating members. Attach covers for flat joints to one seating member; attach angle cover for corner joints to wall.
 4. Fill space between edge of cover plate and raised rim of seating member, flush to finished floor, with flexible filler material suitable to withstand floor traffic, as recommended by the expansion joint manufacturer. Adhere filler to seating member with waterproof adhesive or pressure-sensitive tape.
 5. Provide continuous flexible vinyl moisture seals for weather tight joints, as shown on the Drawings.

2.04 CONSTRUCTION JOINTS AND CONTROL JOINTS

- A. Clean surface of concrete construction joints and remove laitance.
- B. Wet Joints and remove the standing water.
- C. Locate the construction joints in floors within the middle third of spans of slabs,

beams and girders. Offset joints in girders a minimum distance of two times the width of intersecting beams.

- D. Place beams, girders and haunches monolithically as a part of slab system, unless otherwise shown on Drawings or Specifications.
- E. Beams, girders or slabs supported by columns or walls shall not be cast or erected until concrete in vertical support members is no longer plastic.
- F. Spacing:
 - 1. Space control joints in slab on grade at 6 m maximum interval on both directions. The resulting concrete panel shall be approximately square.
 - 2. In concrete walls having frequent openings, spacing control joints 6000 mm apart is considered maximum. Spacing in walls without windows shall not be more than 7500 mm and a joint within 3000 mm of each corner is desirable.
 - 3. Vertical construction joint spacing in concrete walls shall not be more than 12 m and shall be located within the middle third of the span between columns.

PART 3 - EXECUTION

3.01 INSTALLATION

- G. General: Conform to the manufacturer's instructions and recommendations.
- H. Cutting, Fitting and Placement:
 - 4. Perform the cutting, drilling and fitting required for the installation of the items. Set the work accurately in location, alignment and elevation plumb, level, true, measured from established lines and levels.

Provide temporary bracing or anchors in formwork for items which are to be built into concrete, masonry or similar construction.
 - 5. Install joint cover assemblies in true alignment. Set floor covers at elevations to be flush with adjacent finished floor materials. Locate wall, cleaning and soffit covers in continuous contact with adjacent surfaces. Securely attach in place using the required accessories. Locate anchors approximately 75 mm from each end, 300 mm on the center between ends for the set screws and 450 mm on the center between ends for other fasteners, unless closer spacing is recommended by the manufacturer.
 - 6. Hold end joints to the minimum. Make end joints using strong, rigid, mechanical splice plate in true alignment, with hairline joints.

3.02 CLEANING AND PROTECTION

- A. Do not remove strip-protective material until finish work in adjacent areas is complete. When protective material is removed, clean exposed metal surfaces in accordance with the manufacturer's instructions.

SECTION 06100

ROUGH CARPENTRY

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Rough carpentry as well as the related construction, including wood treatment and fastenings, blocking, shims, spacers, and other rough carpentry work as shown on Drawings and as specified in this section.

1.02 REFERENCES

B. ANSI - American National Standards Institute

A199.1 Construction and Industrial Plywood.

C. ASTM - American Society for Testing and Materials

ASTM A 36 Specification for Structural Steel.

ASTM D 4442 Test Method for Direct Moisture Content Measurement of Wood and Wood-Base Materials.

D. AWPA - American Wood Preservers Association

AWPA C1 Timber Products-Pressure Treatment (General Requirements).

AWPA C2 Lumber, Timbers, Bridge Ties and Mine Ties-Pressure-Treatment.

AWPA C9 Plywood-Pressure Treatment.

AWPA C20 Structural Lumber, Fire Retardant-Pressure Treatment.

AWPA M4 Care of Pressure-Treated Wood Products.

E. AWPB - American Wood Preservers Bureau

AWPB LP-2 Standard for Softwood Lumber, Timber and Plywood Pressure Treated with Water-Borne Preservative for above Ground Use.

AWPB LP-3 Standard for Softwood Lumber, Timber and Plywood Pressure Treated with Light Petroleum Solvent-Penta Solution for above Ground Use.

AWPB LP-4 Standard for Softwood Lumber, Timber and Plywood Pressure Treated with Volatile Petroleum Solvent (LPG) - Penta Solution for above Ground Use.

AWPB LP-22 Standard for Softwood Lumber, Timber and Plywood

Pressure Treated with Water-Borne Preservative for Ground Contact Use.

AWPB LP-44 Standard for Softwood Lumber, Timber and Plywood Pressure Treated with Volatile Hydrocarbon Solvent-Penta Solution for Ground Contact Use.

AWPB LP-55 Standard for Softwood Lumber, Timber and Plywood Pressure Treated with Creosote or Creosote Coal tar Solution for Ground Contact Use.

F. USDC - United States Department of Commerce

USDC PS-1 Softwood Plywood, Construction and Industrial.

USDC PS-20 American Softwood Lumber Standard.

1.03 SUBMITTALS

A. Wood Treatment Data

1. Submit chemical treatment as well as manufacturer's instructions for the proper use of each type of treated material.
2. For pressure treatment and each type specified, include certification by treating plant stating chemicals and process used, net amount of salts retained and conformance with applicable standards.
3. For water-borne preservatives, include statement that moisture content of treated materials was reduced to the levels indicated prior to shipment to project site.
4. For fire-retardant treatment, include certification by the treating plant that the treated material complies with the specified requirements and that treatment will not bleed through finished surfaces.

1.04 TRANSPORTATION, HANDLING AND STORAGE

A. Delivery and Storage

1. Keep materials dry during delivery and storage.
2. Protect against exposure to weather and contact with damp or wet surfaces. Stack lumber and plywood while providing air circulation within stacks during storage.

1.05 QUALITY ASSURANCE

- A. Work shall be executed and tested in accordance with the current editions of applicable codes and standards specified in this section.
- B. Lumber Standards: Comply with US Department of Commerce Standard PS-20 **American Softwood Lumber Standards** for each indicated use, including moisture content and actual sizes related to the indicated nominal sizes.

C. Factory Markings and Certificates

1. Factory-mark each piece of lumber with type, grade, mill, and grading agency identification, except omit marking from surfaces to receive transparent finish, and submit mill certificate that material has been inspected and graded in accordance with requirements if it cannot be marked on a concealed surface.
2. Certificate of inspection and grading by a recognized agency may be submitted with each shipment, in lieu of factory-marking, at Contractor's option.

D. Fire-Retardant Marking: Fire-retardant treated wood shall be tested in accordance with ASTM E 84, maximum flame spread of 25. Label materials with Underwriters' Laboratory Seals, showing grade and rating.

E. Shop-fabricate carpentry work to the greatest possible extent, using equipment and workmanship control methods which will result in work of better quality than is feasible for on-site fabrication.

F. Lumber and wood carpentry materials shall be preservative pressure treated.

1.06 JOB CONDITIONS

- A. Examine the substrates and supporting structure and the conditions under which the carpentry work is to be installed, and remedy any conditions detrimental to work. Do not proceed with installation until the satisfactory conditions have been corrected in a manner acceptable to the Installer.
- B. Fit carpentry work to other works as required for accurate fit. Correlate location of furring, nailers, blocking, grounds and similar supports to allow proper attachment of other work.

PART 2 - PRODUCTS

2.01 LUMBER - GENERAL

- C. Nominal sizes of lumber are indicated, except where specific details and dimensions are shown. Provide actual sizes and moisture content for material as specified in PS-20.
- D. Provide dressed lumber, S4S (smooth 4 sides), of an approved specie and of a standard grade.
- E. Provide seasoned lumber with 15 percent maximum moisture content at time of dressing. After pressure treatment, kiln-dry lumber to 15 percent maximum moisture content.
- F. Miscellaneous Lumber: Provide wood for support or attachment of other work as indicated on Drawings.

2.02 PLYWOOD

- A. Concealed Plywood: Where plywood will be concealed by other work, provide interior type plywood C - D, Plugged Grade, unless otherwise specified. Plywood surfaces shall be fire-retardant coated:

- 1. For backing panels for fascia panels, electrical or telephone equipment provide fire-retardant treated standard grade plywood with exterior glue.

2.03 MISCELLANEOUS MATERIALS

- A. Anchors and Fasteners: Select proper type, size, material, and finish for each application.

2.04 WOOD TREATMENT

- A. Preservative Treatment

- 1. General: Preservative-treated lumber, except where indicated for other treatment, to comply with the applicable requirements of the American Wood Preservers Bureau, available from AWPB. Treated items shall be AWPB quality marked for the specified requirements.
 - 2. Pressure treat the following items with water-borne preservative for above ground use, complying with AWPB LP-2. Kiln-dry wood to a maximum moisture content of 15 percent after treatment.
 - a. Wood members in connection with roofing, flashing, vapor barriers, and waterproofing.
 - b. Concealed wood members in contact with masonry, concrete, and below grade.
 - c. Exposed woodwork shown or scheduled as **Treated Wood** and all wood members less than 600 mm above grade.

- B. Pressure treat wood members placed in the ground and in fresh water with below ground water-borne preservatives, complying with AWPB LP-22.

- C. Fire-Retardant Treatment

- 1. General: Where **Fire-Retardant-Treated** lumber is indicated, comply with AWPB standards for pressure impregnation with fire-retardant chemicals to achieve a flame spread rating of not more than 25 when tested in accordance with UL 723, ASTM E 84, or NFPA 855.
 - 2. Where transparent or paint finish is shown or scheduled for Fire-Retardant-Treated wood, use a fire-retardant treatment which will not bleed through or adversely affect bond of finish.
 - 3. Complete fabrication prior to treatment, wherever possible, to minimize cutting and jointing after treatment. Coat surfaces cut after treatment with a heavy brush coat of the same fire-retardant chemical.
 - 4. Kiln-dry lumber and plywood to a maximum moisture content of 15 percent after treatment.

- 5. Inspect each piece of lumber after drying. Do not use twisted, warped, bowed, or otherwise damaged or defective pieces.
 - 6. Provide UL label on each piece of fire-retardant treated lumber and plywood.
- D. Complete fabrication of treated items prior to treatment, wherever possible. If cut after treatment, cut surfaces shall be coated with heavy brush coat of same chemical used for treatment. Each piece of lumber or plywood shall be inspected after drying and damaged or defective pieces shall be discarded.

PART 3 - EXECUTION

3.01 INSTALLATION

- E. Discard units of material which are unsound, warped, bowed, twisted, improperly treated, not adequately seasoned or too small to fabricate the work with a minimum of joints or the optimum jointing arrangement.
- F. Fit carpentry work to other work. Scribe and cope as required for accurate fit. Set carpentry work accurately to required levels and lines with members plumb and true.
- G. Shim with metal or slate for bearing on concrete and masonry substrate. Where indicated, provide with 1-3 Portland cement-sand grout for full-bearing.
- H. Securely attach carpentry work to substrates by anchoring and fastening as shown and as required by recognized standards. Provide washers under bolt heads and nuts in contact with wood. Countersink nail heads on exposed carpentry work and fill holes.
- I. Fasteners: Use common wire nails, except as otherwise shown or specified herein. Use finishing nails for exposed work. Do not wax or lubricate fasteners that depend on friction for holding power. Select fasteners of size that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting of wood; pre-drill as required. Do not drive threaded friction-type fasteners; turn into place. Tighten bolts and lag screws at installation and retighten as required for tight connections prior to closing in or at completion of work.
- J. Wood Grounds, Nailers, Blocking, and Sleepers: Provide wherever shown and where required for screeding or attachment of other work. Form to shapes as shown and cut as required for true line and level of work to be attached or screeded. Coordinate location with related carpentry work; refer to shop drawings for such work when required.
- K. Wood Furring: Install plumb and level with closure strips at edges and openings. Shim with wood as required. Firestop furred spaces on walls at each floor level, with wood blocking or incombustible materials, accurately fitted to close furred spaces. Comply with governing regulations.
- L. Plywood: Where required, shall be complying with the recommendations of the

American Plywood Association (APA) for the fabrication and installation of plywood work.

END OF SECTION

SECTION 06400

ARCHITECTURAL WOODWORK

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Standing And Running Trim.
- B. Kitchen Cabinets.
- C. Wood Paneling (Cladding).
- D. Any Other Architectural Woodworks.

1.02 REFERENCES

A. ASTM - American Society for Testing and Materials

ASTM A 36 Specification for Structural Steel.

ASTM A 307 Specification for Carbon Steel Externally and Internally Threaded Standard Fasteners.

ASTM A 209 Specification for Aluminum Alloy Sheet and Plate.

B. PS - National Bureau of Standards, Product Standards

PS 1 Construction and Industrial Plywood With Typical APA Grade-Trademarks.

PS 51 Product Standard Concerning Standards for the Manufacture of Plywood with Flame Spread Ratings.

C. ANSI - American National Standard Institute

A156.9 Cabinet Hardware.

A616.2 Performance Standards for Fabricated High Pressure Decorative Laminate Counter-top.

A208.1 Mat-Formed Wood Particle-board.

D. NEMA - National Electrical Manufacturer's Association

LD 1 Standard Publication Laminated Thermosetting Decorative Sheets.

LD 3 High Pressure Decorative Laminate.

E. AWI - Architectural Woodwork Institute

AWI Architectural Woodwork Standards, Guide Specifications and

Quality Certification Program.

F. CS - Department of Commerce, Commercial Standards

CS 236 Mat-Formed Wood Particle Board.

G. BHMA - Builder's Hardware Manufacturer's Association

Standard 201 Product Standard.

Section B Cabinet Hardware.

1.03 SUBMITTALS

- A. Product Data: Submit manufacturer's product data for each product and process specified as work of this Section and incorporated into items of architectural woodwork during fabrication, finishing, and installation.
- B. Wood Treatment Data: Submit chemical treatment manufacturer's instructions for handling, storage, installation and finishing treated materials as follows:
 - 1. Non-Pressure Preservative Treatment: Include certification stating chemical solution and submersion period used and affirming compliance with indicated treatment standards.
 - 2. Pressure Preservative Treatment: For each type of treatment and wood species indicated, include certification of treating plant stating type of preservative solution, amount of preservative retained, depth of penetration and compliance with indicated standards.
 - 3. Fire-Retardant Treatment: Include certification by treating plant that treated materials comply with requirements.
- C. Quality Certification: Submit woodwork manufacturer (fabricator) certification, stating that fabricated woodwork complies with quality grades and other requirements indicated.
- D. Shop Drawings: Submit shop drawings showing location of each item, dimensioned plans and elevations, large scale details, attachment devices and other components.
- E. Samples: Submit samples of wood finish and plastic laminates for color and pattern selection, and exposed cabinet hardware (one unit of each type and finish).

1.04 TRANSPORTATION, HANDLING AND STORAGE

- A. Protect woodwork during transit, delivery, storage and handling to prevent damage, soiling and deterioration.
- B. Do not deliver woodwork until painting, wet work grinding and similar operations which could damage, soil or deteriorate woodwork have been completed in installation areas. If, due to unforeseen circumstances, woodwork must be stored in other than installation areas, store only in areas meeting requirements specified for installation areas.

1.05 QUALITY ASSURANCE

- A. Manufacturer and Installer Qualifications: A firm experienced in successfully producing architectural woodwork similar to that required for this project. Manufacturer and the Installer shall be subject to approval of the Engineer.
- B. Work shall comply with applicable requirements of **Architectural Woodwork Quality Standards** published by Architectural Woodwork Institute (AWI), except as otherwise indicated.

PART 2 - PRODUCTS

2.01 BASIC MATERIALS AND FABRICATION METHODS

- C. General: Provide quality grade specified except where work of higher quality is indicated.
- D. Wood Moisture Content: Provide kiln-dried lumber and maintain optimum moisture content in solid wood (hardwood and softwood) through fabrication, installation and finishing operations of interior work. Moisture shall be 10 percent for Interior Woodwork and ranging from 9 to 13 percent for Exterior Woodwork.
- E. Wood for Transparent Finish: Unless otherwise indicated on the Drawings, provide premium grade plain sawn oak, redwood or approved equal specie.
- F. Wood for Painted Finish: Comply with quality standards for selection of species, grade and cut, except as otherwise indicated.
- G. Plastic Laminate: Comply with NEMA LD 1, type, thickness, color, pattern and finish as indicated for each application, or if not indicated, as approved by the Engineer.
- F. Quality Standards: For the following types of architectural woodwork, comply with the indicated standards as applicable:
 - 1. Standing and Running Trim : AWI Section 300.
 - 2. Casework and Counter-tops : AWI Section 400.
 - 3. Panelling : AWI Section 500.
 - 4. Shelving : AWI Section 600.
 - 5. Miscellaneous Work : AWI Section 700.
- G. Design and Construction Features: Comply with the details shown for profile and construction of architectural woodwork and, where not otherwise shown, comply with applicable quality standards with alternate details as fabricator's option.
- H. Pre-Cut Openings: Fabricate architectural woodwork with pre-cut openings, wherever possible, to receive hardware, appliances, plumbing fixtures, electrical work and similar items. Locate openings accurately and use templates or

roughing-in diagrams for proper size and shape. Smooth the edges of cutouts and, where located in counter-tops and similar exposures, seal the edges of cutouts with a water-resistant coating.

I. Wood Treatment

1. Preservative Treatment By Non-Pressure Method: Comply with requirements of referenced woodworking standard for non-pressure treatment of woodwork with non-aqueous water repellent solution, except as indicated. Treat units of woodwork after cutting machining, sanding, gluing and assembling have been completed to the greatest extent possible. Coat surfaces cut after treatment with heavy brush coating of same preservative.
2. Pressure Preservative Treatment: Use only preservative solutions and treating process demonstrated through successful experience and recommended by manufacturer of preservative chemicals and wood treatment plant as being suitable for woodwork of type, species, and finish indicated.
3. Fire-Retardant Treated Wood: Where wood is indicated as **FRTW**, provide materials complying with applicable standards for pressure impregnation with fire-retardant chemicals and with AWPA C-20 for lumber and AWPA C-27 for plywood, and flame spread rating of 25 as per ASTM E 84.

- J. Fabrication and assembly techniques used by the woodworker shall be those established by AWI; and items indicated shall be shop-fabricated and finished to the fullest extent possible.

2.02 STANDING AND RUNNING TRIM

- A. Standing and running trim shall include trim for openings and casings.
- B. Wood used shall be 20 mm thick, hardwood, AWI quality, premium grade, type be as indicated on Drawings.
- C. Match species and cut indicated for other types of transparent finished architectural woodwork located in same area of building, unless otherwise indicated.
- D. Sizes and Shapes: As shown on the Drawings.
- E. Finish: Wood base shall have a clear lacquer finish in accordance with Section 09900 - PAINTING.

2.03 KITCHEN CABINETS:

- A. Kitchen cabinet types:
 1. Where indicated on Drawings, cabinets shall be shop-fabricated complying with AWI Section 400 and its Division 400B or equivalent standards, size and shape as shown on Drawings. Cabinets structure including doors, shelves, drawer and worktops shall be fabricated from minimum 18 mm thick plywood with plastic lamination in both faces, color to match doors. High-pressure decorative plastic laminate, premium

grade, complying with NEMA LD3 shall be minimum 1.50 mm thick for worktops and 0.5 mm thick for other areas, and shall be applied on 18 mm plywood. Cabinet countertop shall have wooden frame support. Exposed supports shall not be acceptable. Exposed counter fittings and supports, where approved, shall be stainless steel type 304 with a polished finish. Manufacturer's standard hardware complying with ANSI/BMHA A156.9, subject to approval of Engineer, shall be provided.

- B. Construction: Submit detailed shop drawings showing the different construction details as well as samples of the materials and finishes involved including color, type, and patterns of laminate, of for the Engineer's review and approval.

2.04 WOOD PANELLING (CLADDING)

- A. Shop-fabricated, premium grade quality complying with AWI Section 500 - Division A. Wood paneling shall be either 19mm MDF panels with plastic laminated veneer finish on MDF wooden studs or 3-6 mm plywood panels with plastic laminated veneer finish on 3-6 mm plywood wooden studs filler as indicated on Drawings. Construction details, color of finish, pattern and grain matching shall be as approved by the Engineer.

PART 3 - EXECUTION

3.01 INSTALLATION

- B. Only the most skilled of workmen shall be used to install the products specified in this section. The quality of workmanship in installation shall match the quality of the product specified.
- C. Install the work plumb, level, true and straight with no distortions. Shim as required using concealed shims. Install to a tolerance of 3 mm in 2400 mm for plumb and level (including tops); and with no variations in flushness of adjoining surfaces.
- D. Cut work to fit adjoining work, and refinish cut surfaces or repair damaged finish at cuts.
- E. Anchor woodwork to anchorage devices or blocking built-in or directly attached to substrates. Secure to grounds, stripping and blocking with countersunk, concealed fasteners and blind nailing as required for a complete installation. Except where pre-finished matching fastener heads are required, use fine finishing nails for exposed nailing, countersunk and filled flush with finished surface, and matching final finish where transparent is indicated.
- F. Tops: Anchor securely to base units and other support systems as indicated.
- G. Prefabricated Woodwork: Install, where shown, securely anchored in accordance with the manufacturer's shop Drawings and instructions.
- H. Fire Retardant Coating: Where required, apply by roller, brush or spray to conform with the manufacturer's application recommendations and instructions.
- I. Plastic Laminates: Apply over substrates indicated in accordance with the

manufacturer's instructions.

3.02 ADJUSTMENT, CLEANING, FINISHING AND PROTECTION

- A. Repair damaged and defective woodwork wherever possible to eliminate defects functionally and visually; where not possible to repair properly, replace woodwork. Adjust joinery for uniform appearance.
- B. Clean hardware, lubricate and make final adjustments for proper operation.
- C. Clean woodwork on exposed and semi-exposed surfaces. Touch up shop-applied finishes to restore damaged or soiled areas.
- D. Complete the finishing work specified as work of this section, not complete at the shop or prior to installation of woodwork.
- E. Protection: Protect architectural woodwork and maintain conditions necessary to ensure that the work will be without damage or deterioration at the time of acceptance.
- F. Anti-Corrosion Measure
 - 1. Incompatible materials are to be isolated with approved materials which can withstand compression.
 - 2. Use only non-ferrous fixing where applicable.
 - 3. Use approved rust inhibitors as pre-primers after primary preparation.

END OF SECTION

SECTION 07100

WATERPROOFING

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Sheet membrane waterproofing for the following:

1. General waterproofing for tanking applications, building basement, swimming pools, fountains and areas below grade as indicated on Drawings.
2. Toilets, washrooms, kitchenettes and other wet areas.
3. Planter boxes.

B. Lining for the following:

1. Water tanks.
2. Swimming pools.
3. Fountains.
4. Lift station, sewer manholes, raw water tanks, sewage tanks and sump pits.

1.02 REFERENCES

A. ASTM - American Society for Testing and Materials

ASTM D 5	Standard Method of Test for Penetration of Bituminous Materials
ASTM D 36	Standard Method of Test for Softening Point of Asphalt (Ring and Ball apparatus)
ASTM D 41	Primer for use with Asphalt in Dampproofing and Waterproofing
ASTM D 146	Sampling and Testing Felted and Woven Fabrics Saturated with Bituminous Substances for use in Waterproofing and Roofing
ASTM D 471	Test Method for Rubber Property - Effect of Liquids
ASTM D 570	Test Method for Water Absorption of Plastics
ASTM D 638	Test Method for Tensile Properties of Plastics
ASTM D 828	Test Method for Tensile Breaking Strength of Paper and

Paperboard

ASTM D 1004	Test Method for Initial Test Resistance of Plastic Film and Sheeting
ASTM E 96	Standard Method of Test for Water Vapor Transmission of Materials
ASTM E 154	Test Method for Water Vapor Retarders Used in Contact with Earth under Concrete Slabs, on walls, or as Ground Cover

1.03 SUBMITTALS

- A. Submit product data, samples, general recommendations from waterproofing materials manufacturer, for types of waterproofing required. Include data showing that materials comply with the specified requirements.

1.04 TRANSPORTATION, HANDLING AND STORAGE

- A. Deliver materials in manufacturer's unopened, labeled packing and in compliance with the manufacturer's storage, handling, installation and protection requirements.

1.05 WARRANTY

- A. Provide written warranty, agreeing to replace and repair defective materials and workmanship. Warranty includes responsibility for removal and replacement of other work which concern sheet waterproofing. Warranty period is 10 years after date of substantial completion.

1.06 QUALITY ASSURANCE

- A. Manufacturer: Obtain primary waterproofing materials of each type required from a single manufacturer, to the greatest extent possible. Provide secondary materials only as recommended by manufacturer of primary materials.

1.07 JOB CONDITIONS

- A. Substrate: Proceed with waterproofing after completing substrate construction, openings and penetrating works.
- B. Weather: Proceed with waterproofing and associated works only when existing and forecast weather conditions permit work to be performed in accordance with manufacturer's recommendations and warranty requirements.

PART 2 - PRODUCTS

2.01 WATERPROOFING MATERIALS

- A. Waterproofing membrane: High performance polymer modified bitumen sheet membrane, 3 and 4 mm thick, reinforced with 200 g/m² non-woven polyester fabric. Membrane shall be fully bonded, torch applied to the primed surface

comply with the following requirements:

- flexible membrane, not effect with room temperature and not adhere under folding .
- Actual thickness 4mm or 3mm +- 5%.
- Weight 4 kg/m² for 4mm thick membrane and 3 kg/m² for 3mm thick membrane.
- Reinforcement 200gm/m² non-woven polyester fiber.
- bitumen content 96.1%.
- Softing point 147C.
- Tensile strength longitudinal 1100N/5cm.
- Tensile strength transversal 700N/5cm.
- Longitudinal and transversal elongation 50%.
- Cold bend test no cracks at 0 C.

B. Waterproofing for water tanks, building basement, swimming pools and fountains:

1. Double membrane applied in 2 layers fully bonded, torch applied to the primed substrate; first layer shall be 4 mm thick and the second layer shall be 3mm thick.

C. Planter boxes: Double membrane (two layers) fully bonded torch applied to the primed substrate as follows:

1. First Layer: 3 mm thick, black finish with fine talcum on one side and a torch-off polyethylene foil fixed to the other side and contains a special anti-root chemical additive.
2. Second Layer: 3 mm thick, finish with mineral granules on the top side and a thin torch-off polyethylene foil fixed to the other side and contains a special anti-root chemical additive.

D. Waterproofing for general wet areas (Kitchens, Toilets and Wash Areas):

1. Single membrane, 4mm thick, fully bonded, torch applied to the primed substrate

E. Lining for water tanks and swimming pools as follows:

1. A Two-component epoxy resin based, non-toxic, high build solvent-free coating applied in two coats, 200 micron thick each, with glass-fiber reinforcement grade 110 g/m² (between coats) on the internal surfaces of the tank unless recommended otherwise by the lining Manufacturer.

F. Lining for fountains as follows:

1. A single component pitch modified polyurethane coating conforming to ASTM C 836 or BS 3900 applied in a single coat, 1.3 mm thick on the internal surfaces as per the recommendations of the lining manufacturer and suitable for surface finishes.

G. Lining for sewer manholes, lift stations, raw water tanks, sewage tanks and

sump pits: Trowel applied to the substrate as follows:

1. A three-component system consisting of epoxy resin without solvents and chemical resistant fillers applied in 2 coats, 300 microns thick each on internal surfaces unless recommended otherwise by the lining Manufacturer.

2.02 MISCELLANEOUS MATERIALS

- A. Primers: Provide the type of primer as recommended by the waterproofing material manufacturer.
- B. Protection Board: Provide 3 mm thick multi-layer pressure bonded board with asphaltic impregnation as a protection for the waterproofing where indicated on the Drawings.
- C. Separation Layer: Non-woven polyester fabric, density 180 g/m² and to be laid above the membrane where shown on Drawings.
- D. Vapor Barrier: Polyethylene sheeting conforming to ASTM E154, minimum 200 microns thick having a vapor permeance rating not exceeding 0.063 perms conforming to ASTM E 96, and shall be laid with 300 mm overlapping.

PART 3 - EXECUTION

3.01 INSTALLATION

- E. General: Waterproofing works shall be executed by a specialized Sub-Contractor recommended by the waterproofing and/or lining manufacturer and approved by the Engineer.
- F. Comply with waterproofing and/or lining manufacturer's recommendations regarding installation details, surface preparation, torch applied process, priming of surfaces as well as the overlapping.
- G. Substrate shall be smooth, hard dry and free from high spots and depressions. Substrate shall be swept clean and free from dust, loose cement scale, oil, grease, foreign substances and debris.
- H. Starting at the low point of the slab, apply the waterproofing membrane fully bonded laid torch applied for horizontal areas with minimum 75 mm overlap. Lay non-woven polyester fabric separation layer over waterproofing membrane prior to application of other finishing.
- I. On vertical areas, apply the waterproofing membrane fully bonded laid torch applied fixed to walls with minimum 75 mm overlap. Use waterproofing manufacturer's standard materials. Apply protection board prior to backfilling.
- J. Test the work after completion by water flooding to a minimum height of 75 mm for a period of 48 hours.

- K. For the application of waterproof lining, follow manufacturer's written instructions.
- L. Submit 10 years guarantee for the waterproofing works done and the associated works covering the failure of materials or workmanship. Guarantee shall be signed by waterproofing Sub-Contractor and shall indicate which (Contractor or Sub-Contractor) has assumed the responsibility for the removal and the replacement of the works concealing the waterproofing work in case of failure of material or workmanship.

END OF SECTION

SECTION 07200

BOARD INSULATION

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Rigid thermal insulation boards for exterior walls and roof as indicated on Drawings and as specified in this section.
- B. Acoustical rockwool insulation for gypsum board wall cladding and partitions as indicated on Drawings and as specified in this section.
- C. Miscellaneous materials related to rigid insulation boards.

1.02 REFERENCES

B. ASTM - American Society for Testing and Materials

ASTM C 518 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the HEAT Flow Meter Apparatus

ASTM C 578 Specification for Preformed, Cellular Polystyrene Thermal Insulation

ASTM D 1621 Test Method for Compressive Properties of Rigid Cellular Plastics

ASTM E 84 Test Method for Surface Burning Characteristics of Building Materials

ASTM E 119 Test Method for Fire Tests of Building Construction and Materials

ASTM E 136 Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C

1.03 SUBMITTALS

- A. Product Data and Samples: Submit manufacturer's product data and samples as well as installation procedures for the Engineer's approval.

1.04 TRANSPORTATION, HANDLING AND STORAGE

- A. Store insulation materials in weathertight enclosure.
- B. Protect insulation from damage from handling, weather and construction operations before, during and after installation.

0.05 QUALITY ASSURANCE

- A. Thermal Resistance: Where thermal resistance properties of insulating materials are designated by R-values they represent the rate of heat flow through a material of thickness indicated, measured by test method included in referenced material standard or otherwise indicated.
- B. Fire Performance Characteristics: Provide insulation materials which are identical to those whose fire performance characteristics, as listed for each material or assembly of which insulation is a part, have been determined by testing, in accordance with the methods indicated below:
 - Surface Burning Characteristics: ASTM E 84
 - Fire Resistance Ratings: ASTM E 119
 - Combustibility Characteristics: ASTM E 136

PART 2 - PRODUCTS

2.01 INSULATION MATERIALS

- A. General: Provide insulating materials to comply with the requirements indicated for materials and compliance with referenced standards, in sizes to fit applications indicated, selected from the manufacturer's standard products for size and thickness.
- B. Rigid Insulation Board for External Walls: In accordance with the following:
 - 1. Construction: Close-celled, extruded polystyrene rigid foam, thickness as shown on Drawings, with integral high density skin, conforming to ASTM C 578 or DIN 18164 Part 1; flame spread rating of 25 or less when tested in accordance with ASTM E 84; 5-year aged average thermal conductivity of 0.032 W/mK when tested at 24°C in accordance with ASTM C 518; water vapor permeability of 0.60 perm-inch average; average water absorption of maximum 1 percent by volume; with rebate details on four edges of board.
 - 2. Rigid wall insulation boards shall have compressive strength of 160 kPa average when tested according to ASTM D 1621 and minimum density 26 kg/m³.
- C. Rigid Insulation Board for Roof: In accordance with the following:
 - 1. Construction: Close-celled, extruded polystyrene rigid foam, thickness as shown in drawings, with integral high density skin, conforming to ASTM C 578 or DIN 18164 Part 1; flame spread rating of 25 or less when tested in accordance with ASTM E 84; 5-year aged average thermal conductivity of 0.032 W/mK when tested at 24°C in accordance with ASTM C 518; water vapor permeability of 0.60 perm-inch average; average water absorption of maximum 1 percent by volume; with rebate details on four edges of board.
 - 2. Rigid roof insulation boards shall have compressive strength of 300 kPa average when tested according to ASTM D 1621 and minimum density 32 kg/m³.
- D. Acoustical Rockwool Insulation: Shall conform to the following requirements:

- 1 Construction: Rockwool fibers insulation produced from molten basalt rock and bonded with thermosetting resin to produce semi-rigid insulation boards complying with ASTM C 612 or wired matt (blanket) conforming to ASTM C 592.
- 2 Size: Manufacturer Standard.
- 3 Thickness: as indicated on Drawings.
- 4 Density: As recommended by the manufacturer to achieve required STC ratings of 45 to 50, but not less than 60 kg/m³.
- 5 Moisture Absorption: Water repellant, non-hydroscopic, and non-capillary. Moisture absorption shall be less than 1% by volume when tested in accordance with BS 2972.
- 6 Fire Rating: Non-combustible with zero flame spread and zero ignitability when tested in accordance with BS 476:Part 4, 5 and 6.

2.02 MISCELLANEOUS ITEMS

- A. Adhesives, tapes, mechanical fastening devices and items necessary for installation of insulation system shall be of types as recommended by the manufacturer.

PART 3 - EXECUTION

3.01 INSPECTION

- B. Examine areas scheduled to receive insulation and space allocated for insulation for proper depth to receive material.

3.02 INSTALLATION

- A. Apply insulation units to substrate by methods complying with manufacturer's recommendation.
- B. If no specific methods are indicated, bond units to the substrate with adhesive or use mechanical anchorage to provide permanent placement and support of units.

3.03 CLEAN UP

- A. Leave work areas in a clean condition after the completion of installation. Remove and dispose off site all excess materials, litter and debris.

END OF SECTION

SECTION 07500

ROOFING

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Inverted roofing system and the integral accessories related to the system installation as indicated on Drawings and as specified in this section.
- B. Green roofing system and the integral accessories related to the system installation as indicated on Drawings and as specified in this section.

1.02 REFERENCES

B. ASTM - American Society for Testing and Materials

ASTM C 495	Test Method for Compressive Strength of Lightweight Insulating Concrete
ASTM D 5	Standard Method of Test for Penetration of Bituminous Materials
ASTM D 36	Standard Method of Test for Softening Point of Asphalt (Ring and Ball apparatus)
ASTM D 41	Primer for use with Asphalt in Dampproofing and Waterproofing
ASTM D 146	Sampling and Testing Felted and Woven Fabrics Saturated with Bituminous Substances for use in Waterproofing and Roofing
ASTM D 471	Test Method for Rubber Property - Effect of Liquids
ASTM D 570	Test Method for Water Absorption of Plastics
ASTM D 638	Test Method for Tensile Properties of Plastics
ASTM D 828	Test Method for Tensile Breaking Strength of Paper and Paperboard
ASTM D 1004	Test Method for Initial Test Resistance of Plastic Film and Sheeting
ASTM E 84	Test Method for Surface Burning Characteristics of Building Materials
ASTM E 96	Test Methods for Water Vapor Transmission of Materials
ASTM E 119	Test Method for Fire Tests of Building Construction and

Materials

ASTM E 136	Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C
ASTM E 154	Test Method for Water Vapor Retarders Used in Contact with Earth under Concrete Slabs, on walls, or as Ground Cover

1.03 SUBMITTALS

- A. Product Data: Submit specifications, installation instructions, and general recommendations from the roofing materials manufacturer for each type of roofing product required. Include the manufacturer's data substantiating that the materials used are in compliance with the requirements.
- B. Samples: Submit samples of each roofing system material for the Engineer's approval.
- C. Shop Drawings: Submit complete shop drawings showing roof configurations and sheet layout, perimeter details as well as special conditions.

1.04 TRANSPORTATION, HANDLING AND STORAGE

- A. Deliver materials in the manufacturer's unopened, labeled packing, and conform to the manufacturer's storage, handling, installation and protection requirements.

1.05 WARRANTY

- A. Provide a written warranty, signed by the Manufacturer of the primary roofing materials and the Installer, agreeing to replace and repair defective materials and workmanship for a period of 10 years starting from date of substantial completion.

1.06 QUALITY ASSURANCE

- A. Manufacturer: Provide primary products for the roofing system produced by a single manufacturer to the greatest possible extent. Provide secondary products which are acceptable to the manufacturer of primary products.
- B. Installation: Work under this Section shall be performed by a specialized Sub-Contractor approved by the Engineer, recommended by the waterproofing membrane manufacturer, and having at least 10 years experience in successfully completed projects.
- C. Thermal Resistance: Where thermal resistance properties of insulating materials are designated by the R-values they represent the rate of heat flow through a material of thickness indicated, measured by the test method included in the referenced material standard or as otherwise indicated.
- D. Fire Performance Characteristics: Provide insulation materials which are identical to those whose fire performance characteristics, as listed for each material or assembly of which insulation is a part, have been determined by testing according to the methods indicated below:
 - 1. Surface Burning Characteristics: ASTM E 84 or equivalent standards.

2. Fire Resistance Ratings: ASTM E 119 or equivalent standards.
3. Combustibility Characteristics: ASTM E 136 or equivalent standards.

1.07 JOB CONDITIONS

- A. Weather: Proceed with roofing work when the existing and forecasted weather conditions permit work to be performed in accordance with the manufacturer's recommendations and warranty requirements.

PART 2 - PRODUCTS

2.01 INVERTED ROOFING SYSTEM

- A. Roof Screed: Lightweight concrete with oven dry density of 640 - 800 Kg/m³, when tested as per ASTM C 495 and minimum compressive strength 3 MPa, when tested in accordance with ASTM C 495. Foaming agent shall be as recommended by the Manufacturer. Mix design shall be as recommended by the manufacturer and approved by the Engineer. Thickness as recommended by the manufacturer (but not less than 50 mm thick), and shall be applied to roof to maintain the required slope.
- B. Roofing Membrane (Covered Areas): High performance polymer modified bitumen single ply waterproofing membrane, 4 mm thick, with double reinforcement consisting of 150 g/m² non-woven polyester fiber and 50 g/m² non-woven glass fiber, to be partially bonded to the concrete surface, comply with the following minimum requirements:
 - flexible membrane, not effect with room temperature and not adhere under folding .
 - Actual thickness 4mm +- 5%.
 - Weight 4 kg/m².
 - double reinforcement consisting of 150 g/m² non-woven polyester fiber and 50 g/m² non-woven glass fiber.
 - bitumen content 96.1%.
 - Softing point 147C.
 - Tensile strength longitudinal 1100N/5cm.
 - Tensile strength transversal 700N/5cm.
 - Longitudinal and transversal elongation 50%.
 - Cold bend test no cracks at 0 C.
1. Roofing Membrane Accessories shall include but not limited to the following:
 - a. Primer for Application to Concrete Surfaces: As recommended by the roofing membrane manufacturer.
 - b. Fillet: Use preformed extrusions of size as mentioned on Drawings, coated with self-adhesive compound to provide an angle fillet between walls and slab.
 - c. Mastic Sealer: Manufacturer's standard elastomeric compound,

heated in accordance with manufacturer's installation procedure to seal waterproofing membrane around projections and irregularities such as gullies and small diameter openings.

- C. Roof Thermal Insulation: Rigid insulation boards, and in accordance with the following:
 - 1. Construction: Close-celled, extruded polystyrene rigid foam, thickness as shown in drawings, with integral high density skin, conforming to ASTM C 578 or DIN 18164 Part 1; flame spread rating of 25 or less when tested in accordance with ASTM E 84; 5-year aged average thermal conductivity of 0.032 W/mK when tested at 24°C in accordance with ASTM C 518; water vapor permeability of 0.60 perm-inch average; average water absorption of maximum 1 percent by volume; with rebate details on four edges of board.
 - 2. Rigid roof insulation boards shall have compressive strength of 300 kPa average when tested according to ASTM D 1621 and minimum density 32 kg/m³.
- D. Separation Layer: Non-woven polyester fiber of a minimum density of 180 g/m² and to be laid above the roof insulation.
- E. Protection Layer: High density polyethylene sheeting conforming to ASTM E 154, 250 microns thick. Similar material having a vapor permeance rating not more than 0.3 perm as determined by ASTM E 96.
- F. Flashing Materials: Manufacturer's standard extruded aluminum system compatible with the roofing membrane.
- G. Roof Topping: Provide one or both of the following roof toppings as indicated on Drawings:
 - 1. Gravel Surfacing: Where indicated on Drawings, provide round edge pea gravel aggregates with diameter size of 15 - 30 mm, and total thickness of 50 mm only for areas shown on the Drawings.
 - 2. Precast Concrete Tiles: Where indicated on Drawings, provide concrete tiles, manufactured by hydraulic pressing; an upper layer of minimum 10 mm thickness formed of 1-1 cement-sand mortar and a lower layer of 30 MPa concrete; and a water absorption of maximum 5 percent. Tile shall have a smooth trowel finish. Tile size shall be 400 x 400 x 40 mm or as indicated on Drawings.

2.02 GREEN ROOFING SYSTEM

Green roofing system shall consist of the following:

- A. Roof Screed: Lightweight concrete with oven dry density of 640 - 800 Kg/m³, when tested as per ASTM C 495 and minimum compressive strength 3 MPa, when tested in accordance with ASTM C 495. Foaming agent shall be as recommended by the Manufacturer. Mix design shall be as recommended by the manufacturer and approved by the Engineer. Thickness as recommended by the manufacturer (but not less than 50 mm thick), and shall be applied to roof to maintain the required slope.

- B. Roofing Membrane: Shall be 1.5 mm PVC High quality waterproofing membrane, with polyester reinforcement, to be applied loose laid to the concrete surface.
- C. Separation Layer: Non-woven polyester fiber of a minimum density of 180 g/m² and to be laid above the roof insulation.
- D. Manufacturer standard 62 mm water storage/drainage layer as approved by the Engineer.
- E. Roof Thermal Insulation: Rigid insulation boards, and in accordance with the following:
 - 1. Construction: Close-celled, extruded polystyrene rigid foam, 25mm thickness as shown in drawings, with integral high density skin, conforming to ASTM C 578 or DIN 18164 Part 1; flame spread rating of 25 or less when tested in accordance with ASTM E 84; 5-year aged average thermal conductivity of 0.032 W/mK when tested at 24°C in accordance with ASTM C 518; water vapor permeability of 0.60 perm-inch average; average water absorption of maximum 1 percent by volume; with rebate details on four edges of board.
 - 2. Rigid roof insulation boards shall have compressive strength of 300 kPa average when tested according to ASTM D 1621 and minimum density 32 kg/m³.
- F. Manufacturer standard separation stabilfilter Layer as approved by the Engineer.
- G. Flashing Materials: Manufacturer's standard extruded aluminum system compatible with the roofing membrane.
- G. Green Roof Topping: Provide both of the following roof toppings as indicated on Drawings:
 - 1. ON the green area surface:
 - a. 100mm thick roof garden agriculture soil mixed with sand, agriculture soil shall be covered with ground cover plants as per requirement of section 02900- LANDSCAPING
 - b. Gravel Surfacing: Where indicated on Drawings, provide round edge pea gravel aggregates with diameter size of 15 - 30 mm, and total thickness of 50 mm only for areas shown on the Drawings.
 - 2. ON the walk area surface:
 - a. Compacted clean sand bed of thickness as shown on Drawings.
 - b. 65 mm concrete tiles (Interlocking paver units): Units shall be of a solid construction and manufactured using 30 MPa portland cement concrete with type I cement under hydraulic pressing and high frequency. Units shall have minimum compressive strength 58 Mpa and water absorption of maximum 5 percent. Sizes and shape as of concrete tiles pavers shall be as indicated on Drawings. Color and texture shall be as selected and approved by the Engineer

3. Green area surface shall be separated than walk area surface by granite stone edging curb on plain concrete bed as shown on Drawings. Granite stone edging curb size, shape and type shall be as indicated on Drawings and as approved by the Engineer.

2.03 FEPS CONCRETE , ROOF COAT AND ELASTOCRYL

- This option of roofing is a simple technology that does not required high trained labor, as it is using Foam Concrete as a versatile building material with a simple production method that is relatively inexpensive compared with other options.
- The foam concrete is a light density product may be cut into different sizes.
- High thermal and acoustical insulation material.
- The foam concrete is produced in a variety of densities from 200 kg/m³ to 1,600 kg/m³ depending on the application
- Faster construction using cast-in-situ application.
- Reduced cost of raw materials; by adding air, enclosed in foam bubbles, the volume of concrete can be increased at very low cost.
- Foamed concrete construction process typically required a slurry of cement and fly ash or sand and water, although some suppliers recommend pure cement and water with the foaming agent for very lightweight mixes.



PART 3 - EXECUTION

3.01 GENERAL:

- C. Roof waterproofing works shall be executed by a specialized Sub-Contractor recommended by the waterproofing membrane manufacturer and approved by the Engineer.

3.02 INVERTED ROOFING SYSTEM

A. Preparation of Substrate:

1. After completion and curing of roof screed, inspect condition of substrate to receive roofing system, and conditions under which work will be performed. Correct unsatisfactory conditions including inadequate provisions in substrate for bonding roofing. Do not proceed with roofing work until unsatisfactory conditions have been corrected.
2. Install cant strips, fillets, and accessory items as indicated, or as recommended by the manufacturer even though not shown on Drawings.

B. Roofing Membrane Installation

1. Installation details: Perform external and internal corners, upstands, drainage and pipes penetrations strictly in accordance with details shown on the Drawings and as recommended by the manufacturer.
2. Substrate shall be smooth, hard dry and free from high spots and depressions. Substrate shall be swept clean and free from dust, loose cement scale, oil, grease, foreign substances and debris.
3. Unroll and align membrane. Re-roll. Bond to primed substrate by melting underside of membrane with gas burner. Lap seams minimum 75 mm, and seal seam with hot trowel and excess mastic sealer. The roofing membrane shall be partially adhered to the primed substrate.
4. The laying of the roofing membrane shall commence from the lowest point when laid on a surface to falls to ensure weathered overlaps.
5. Installation details (i.e. external and internal corners, upstands, drainage and pipes) shall be carried out strictly in accordance with those shown on the drawings and as recommended by the manufacturer.
6. On vertical areas, apply the UV stabilized waterproofing membrane fully adhered to exposed areas of parapet walls with minimum 50 mm overlap.
7. Test roof membrane after completion by flooding 75 mm water height for a period of 48 hours.

C. Insulation Installation

1. Comply with insulation manufacturer's written instruction for particular conditions of installation. Lay polyethylene sheet protection layer over waterproofing membrane prior to installation of insulation boards.
2. Extended insulation full thickness over entire area to be insulated. Cut and fit tightly around obstructions and fill voids with insulation. Remove projection interfering with placement.

3. Lay non-woven polyester fiber separation layer over insulation prior to installation of roof topping.

D. Roof Topping

1. After completing waterproofing membrane, composite flashing and set-on accessories, as well as laying the insulation on each substantial area of roofing, cover the area with the separation layer.
2. Provide one or both of the following roof toppings as indicated on Drawings and as follows:
 - a. Aggregate Surfacing: Loose-fill the surface with a uniform layer of pea gravel 50 mm thick.
 - b. Concrete Tiles: Lay concrete tiles size 400 x 400 x 40 mm with concrete mortar.

3.03 GREEN ROOFING SYSTEM

A. Green Roofing Installation

1. Green roofing installation shall be installed as per the manufacturer instructions and recommendations and as per the Engineer approval.

3.04 PROTECTION OF ROOFING

- A. Protect roofing upon completion of roofing work and during the remainder of construction period. At the end of construction, or at the time when remaining construction work will in no way affect or endanger the roofing, make a final inspection of roofing and prepare a written report describing the nature and the extent of deterioration or damage found in work.
- B. Repair or replace the deteriorated or the defective work found at time of final inspection. Repair or replace the roofing and associated work to a condition free of damage and deterioration at time of substantial completion.

END OF SECTION

SECTION 08100

HOLLOW METAL DOORS AND FRAMES

1. PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Architectural and security hollow metal doors and frames as shown on the Drawings and as specified herein.

1.02 REFERENCES

A. ASTM - American Society for Testing and Materials

ASTM A 36 Structural steel

ASTM A 164 Electro-deposited coating of Zinc on Steel

ASTM A 307 Carbon Steel externally and Internally threaded
Standard Fasteners

ASTM A 366 Steel sheets, Carbon, cold-Rolled Commercial Quality

ASTM A 525 General Requirement for Steel Sheet, Zinc-Coated
(Galvanized) by the Hot Dip Process

ASTM A 526 Steel Sheet, Zinc-Coated (Galvanized) by the Hot Dip
Process, Commercial Quality

ASTM A 569 Steel Carbon (0.15 Maximum Percent) Hot-Rolled sheet
and Strip, Commercial Quality

ASTM E 90 Laboratory Measurement of Airborne Sound
Transmission Loss of Building Partitions

ASTM F 1450 Standard Test Methods for Hollow Metal
Swinging Door Assemblies for Detention Facilities

ASTM F 1577 Standard Test Methods for Detention Locks for
Swinging Doors

B. FS - Federal Specification

FS-S-325 Shield Expansion, Nail Expansion and Nail Drive Screw
(Devices, Anchoring, Masonry)

C. ANSI - American National Standard Institute

A.115 Specifications for Door and Frame Preparation for
Hardware

D. SDI - Steel Door Institute

SDI 100 Standard Steel Doors and Frames

E. NFPA - National Fire Protection Association

NFPA 80 Fire Doors and Windows

F. NAAMM – National Association of Architectural Metal Manufacturer

HMMA 863 Guide Specifications for Detention Security
Hollow Metal Doors and Frames.

1.03 SUBMITTALS

- A. Product Data: Submit manufacturer's specifications for fabrication and installation, including data substantiation that products comply with requirements.
- B. Shop Drawings: Submit for fabrication and installation of metal doors and frames. Include details of each frame type, elevations of door design types, conditions at openings, details of construction, location and installation requirements of finish hardware and reinforcements, and details of joints and connections. Show anchorage and details of joints and connections. Show anchorage and accessory items. Provide schedule of doors and frames using same reference numbers for details and openings as shown on Drawings.
- C. Samples
 - 1. Submit 300 mm x 300 mm section sample of door showing internal construction, edge detail and reinforcement for butts for the Engineer review and approval.
 - 2. Submit 300 mm x 300 mm L-section sample of frame showing corner detail and 300 mm long samples of removable stop for the Engineer review and approval.

1.04 TRANSPORTATION, HANDLING AND STORAGE

- A. Deliver, store and handle hollow metal work in a manner to prevent damage and deterioration.
- B. Provide packaging such as cardboard or other containers, separators, banding, spreaders and paper wrappings to protect hollow metal items.
- C. Store doors and frames upright, in a protected dry covered area, at least 100 mm or more above ground or floor and at least 6 mm between individual pieces.
- D. Doors and frames are to have a metal tag with the door number thereon.

1.05 WARRANTY

- A. Submit a written 2 years guarantee, starting from substantial handover of the project, for all items specified under this Section, signed by manufacturer and the contractor, against all the defects, including bowing, and twisting.

1.06 QUALITY ASSURANCE

- A. General: Unless otherwise specified, provide doors and frames complying with the Steel Door Institute Specifications - Standard Steel Doors and Frames (ANSI/SDI- 100).
- B. Fire-Rated Door Assemblies: Provide doors and frames complying with NFPA 80 or ASTM E 152 and which are labeled and listed by UL, FM or other testing agency acceptable to the Engineer.
- C. Manufacturer: Provide doors and frames from a single manufacturer approved by the Engineer.

2. PART 2 - PRODUCTS

2.01 MATERIALS

- A. Hot-Rolled Steel Sheets and Strip: Commercial quality carbon steel, pickled and oiled, complying with ASTM A 569 and ASTM A 568.
- B. Cold-Rolled Steel Sheets: Commercial quality carbon steel, complying with ASTM A 366 and ASTM A 568.
- C. Galvanized Steel Sheets: Zinc-coated carbon steel sheets of commercial quality, complying with ASTM A 526 with ASTM A 252 G-60 zinc-coating, mill phosphatized.
- D. Reinforcement Steel: ASTM A 36.
- E. Core Material: Manufacturer's standard sound-deadening and heat-retarding mineral fiberglass insulating material.
- F. Supports and Anchors: Fabricated of 1.25 mm thick, galvanized sheet steel.
- G. Inserts, Bolts and Fasteners: Manufacturer's standard units, except hot-dip galvanize items to be built into exterior walls, complying with ASTM A 153, Class C or D as applicable.
- H. Shop Applied Paint: Rust-inhibitive enamel or paint, either air-drying or baking, suitable as a base for specified finish paints. Finish painting shall comply with the requirements of Section 09900 - PAINTING.

2.02 FABRICATION - GENERAL

- A. Fabricate metal door and frame units to be rigid, neat in appearance and free from defects (warp or buckle). Wherever practicable, fit and assemble units in manufacturer's plant. Clearly identify work that cannot be permanently factory-assembled before shipment, to assure proper assembly at project site.
- B. Fabricate exposed faces of doors and panels, including stiles and rails of non-flush units, from only cold-rolled steel.
- C. Fabricate frames, concealed stiffeners, reinforcement, edge channels, louvers and moldings from either cold- rolled or hot-rolled steel.
- D. Fabricate exterior doors, panels, and frames from galvanized sheet steel. Close top and bottom edges of exterior doors as an integral part of the door construction or by addition of inverted steel channels.
- E. Exposed Fasteners: Unless otherwise indicated, provide countersunk flat heads for exposed screws and bolts.
- F. Finish Hardware Preparation
 - 1. Prepare doors and frames to receive mortised and concealed finish hardware in accordance with Hardware Schedule and templates provided by hardware supplier. Comply with applicable requirements of ANSI A115 series specifications for door and frame preparation for hardware.
 - 2. Reinforce doors and frames to receive surface- applied hardware. Drilling and tapping for surface-applied finish hardware may be done at project site.
 - 3. Locate finish hardware as shown on final shop drawings or, if not shown, in accordance with Recommended Locations for Builder's Hardware, Published by Door and Hardware Institute.
- G. Shop Painting - Primer
 - 1. Clean, treat, and paint exposed surfaces of steel door and frame units, including galvanized surfaces.
 - 2. Clean steel surfaces of mill scale, rust, oil, grease, dirt, and other foreign materials before application of paint.
 - 3. Apply shop coat of prime paint of even consistency to provide a uniformly finished surface ready to receive finish paint.

2.03 PRESSED METAL FRAMES

- A. General: Provide continuous type pressed metal frames, including glazing stops and reinforcement, of various profiles to suit conditions detailed on

the drawings and be constructed of new prime quality, hot or cold-rolled sheet steel. Exterior frames shall be fabricated from zinc-coated sheet chemically treated after fabrication for optimum paint adhesion.

- B. Materials: Provide pressed metal frame of the following minimum thickness:
1. Exterior Frames: 1.9 mm thick.
 2. Interior Frames: 1.6 mm thick for openings that are 1 m wide or less and 1.9 mm thick for openings wider than 1 m.
 3. Exterior frames shall be provided with a weather striping, 2 mm thick.
 4. Wall Anchors: Same thickness and material as frame.
 5. Frame Splines: Same thickness and material as frames.
 6. Hinge Reinforcement: 250 x 40 x 5 mm, unless recommended otherwise by the manufacturer.
 7. Strike Reinforcement: 100 x 40 x 5 mm unless recommended otherwise by the manufacturer.
 8. Closer and Holder Reinforcement: 5 mm by the required length and width.
- C. Frames: Provide frames that have joints die-mitered with integral tabs for reinforcement and interlocking of the jambs to head. Frames shall be knockdown or equivalent, with self aligning tabs and slots for securely locked corners.
- D. Security Frames: Security metal frames indicated as security grade on drawings shall be standard heavy duty product produced by single manufacturer specialist in this production range. Security grade frame manufacturer and materials shall be subject to the Engineer approval.

Security metal frames shall be manufactured of heavy gauge steel sheets (12 gauge minimum) with additional reinforcing stiffeners and shall be with smooth edges and without any exposed removable parts. Security metal frames steel sheets shall be cold-rolled steel sheets conforming to ASTM A 366 or hot-rolled steel sheets conforming to ASTM A 569, steel sheets shall have zinc coating conforming to ASTM A 653.

Frames shall be welded units of the sizes and types shown on Drawings and shall comply with National Association of Architectural Metal Manufacturer Specifications - Guide Specifications for Detention Security Hollow Metal Doors and Frames -(HMMA 863), and shall be tested according with ASTM F 1450 and ASTM F 1577.

Security grade metal frames shall be installed as per the manufacturer instructions and recommendations.

- E. Construction: The finished work shall be strong and of rigid construction neat in appearance and free from warp, wave and buckle. Molded members shall be clean cut, straight and true. Miters shall be well formed and in true alignment. Fastenings shall be concealed where practicable.
- F. Door Silencers: Except on weatherstripped frames, drill stops to receive 3 rubber silencers on strike jamb of single-swing frames and 4 silencers on heads of double-swing frames.
- G. Anchors
 - 1. Unless otherwise indicated on drawings, anchor frame in concrete and masonry walls by means of galvanized expansion shields and flat-head machine screws. Screw heads shall be counter-sunk in soffit of jamb. Machine screws shall be approved type, 9 mm diameter by minimum 75 long of zinc plated or dichromated steel with 9 mm diameter by minimum 44 mm long malleable iron or steel expansion shield. Reinforce jamb at each expansion screw location with 5 mm by 38 mm wide steel fitting into inside of stop and welded to backbends. Anchors shall be located not more than 150 mm from top and bottom of each jamb with intermediate anchors spaced at a maximum of 650 mm on center.
 - 2. Anchors for plaster partitions with truss stud framing shall be Z-clip type, to be secured to studs and welded to back of frames above each hinge reinforcement and just below the top hinge reinforcement. Anchors on the strike side shall occur directly opposite to those on the hinge side.
 - 3. Provide at least 4 anchors for each jamb for frames up to 2.28 m in jamb height; 5 anchors up to 2.40 m; and one additional anchor for each 0.6 m fraction thereof over 2.4 m jamb height.
- H. Bottoms of frames shall have not less than 2.8 mm thick welded-on floor clips punched for two 6.4 mm expansion bolts or shot pins. Return bends of frames shall be flanged.
- I. Temporary channel or angle spreaders shall be tack-welded to bottom of frames to prevent distortion during shipment and storage and shall hold the frames in proper position until adjacent construction has been completed.

2.04 HOLLOW METAL DOORS

A. Door Types

- 1. Interior doors: Fabricate interior hollow metal doors of

2 outer sheets, 1.2 mm thick cold rolled stretcher-level sheet steel, free from rust, scale, pits and surface defects. Unless otherwise indicated on Drawings, hollow metal door thickness shall be 44mm.

2. Exterior doors: Fabricate exterior hollow metal doors of 2 outer sheets, 1.6 mm thick zinc-coated bonderized sheet steel. Provide exterior doors with spring tension type (aluminum or corrosion resisting steel) or integral elastomeric type (synthetic rubber, vinyl or neoprene) standard weather stripping at doors in accordance with the manufacturer's instructions and as approved by the Engineer. Unless otherwise indicated on Drawings, hollow metal door thickness shall be 44mm.
3. Metal Louvered Doors: Shall be manufacture's standard product fabricated of 18 gauge cold-rolled sheet metal, free from rust, scale, pits and surface defects. Door thickness shall be 44 mm. Stile channels, stiffener channels and other construction members shall be of sizes as recommended by the manufacturer. All exposed joints or seams shall be fully welded, filled and ground smooth to the Engineer satisfaction.
4. Service Heavy-Duty Doors: Fabricate service doors using same sheet facing thickness as that for interior or exterior doors as per door location. Provide additional reinforcing stiffeners for the door construction.
5. Security Doors: Security metal doors indicated as security grade door on drawings shall be standard heavy duty products produced by single manufacturer specialist in this production range. Security grade door manufacturer and materials shall be subject to the Engineer approval.

Doors shall be manufactured of heavy gauge steel sheets 14 gauge minimum as per use function requirements with additional reinforcing stiffeners and shall be with smooth edges and without any exposed removable parts. Doors steel sheets shall be cold-rolled steel sheets conforming to ASTM A 366 or hot-rolled steel sheets conforming to ASTM A 569, steel sheets shall have zinc coating conforming to ASTM A 653.

Doors types, sizes and grades shall be as shown on Drawings.

Where required as indicated on door type schedule drawing, provide doors with pans for hands, food pass, speaker opening, metal shelf with metal support, security metal wire mesh and vision security glass panels of thickness indicated on Drawings.

Security door including frame shall be 220 Kg weight minimum and shall be installed by professional contractor recommended from the

manufacturer. Security grade Doors shall be installed as per the manufacturer instructions and recommendations.

Security metal doors shall comply with National Association of Architectural Metal Manufacturer Specifications - Guide Specifications for Detention Security Hollow Metal Doors and Frames -(HMMA 863), and shall be tested according with ASTM F 1450 and ASTM F 1577.

B. Door Construction

1. Doors are to have continuous internal reinforcing channels or z-shaped members, 1.5 mm thick steel, full height of door, spaced not more than 150 mm on center and spot welded to face sheets 75 mm on center. Doors with continuous truss inner core, full height and width, spot welded to face sheets at 75 mm on center both vertically and horizontally are also acceptable.
2. Provide 0.9 mm thick stile channels and 1.9 mm thick horizontal stiffener channels at top and bottom of doors welded to face sheets.
3. Fill hollow portions of doors shall be filled completely with expanded polyurethane, mineral fiberglass or rock wool or an approved equal filler.
4. Exposed joints shall be fully welded, filled and ground smooth.
5. Interlocking joints or seams are not approved on faces or edges.
6. Provide single swing doors with not more than 3 mm clearance at jambs and heads and not more than 6 mm clearance at meeting edges of pair of doors (3 mm on fire rated doors).
7. Doors shall have a 3 mm in 50 mm bevel on the strike side.
8. Where required as indicated on door type schedule drawing, provide doors with grills and vision glass panels of thickness indicated on Drawings.

C. Heads and jambs of doors shall be flush constructed unless otherwise shown. Fire rated door pairs shall be provided with astragal intumescent protection strip unless otherwise shown.

D. Undercutting: Undercut doors a maximum of 19 mm at bottom except toilet doors which shall be undercut a minimum of 30 mm, unless directed otherwise by the Engineer and unless otherwise shown in drawings.

E. Reinforcement: Provide reinforcement for finish hardware as follows:

1. Reinforcement for butts shall be not less than 5 mm thick by 230

mm long and 6 mm narrower than the thickness of the door.

2. Reinforcing plates for closers, holders, and stops shall be not less than 5 mm thick and by template requirements as to length and width.
 3. Reinforcement for locks and escutcheons shall be not less than 1.9 mm thick steel, with spring leaf contacts for lock cases.
 4. Reinforcement for exit devices and mortised or surface applied hardware shall be not less than 2.6 mm thick and by template requirements as to length and width.
- F. Tolerances: provide door panels that are free from buckles, twists or other imperfections. Do not use panels having a buckle exceeding 1.5 mm, as determined by a straight edge applied to the face of the panel.

2.05 SHOP FINISH

- A. Carry out shop finishing of metal doors and frames as follows:
1. Fill door edges with mineral filler to conceal seams.
 2. Chemically treat non galvanized, non bonderized metal surfaces with a phosphate compound to assure maximum paint adherence.
 3. Thoroughly clean all metal surfaces of all rust, scale, grease, rough spots and other foreign matter which may prevent proper paint adhesion.
 4. Apply dip or spray coat of rust-inhibitive metallic oxide zinc chromate or synthetic resin primer on all surfaces of frames and on all exposed surfaces of doors and panels. Exposed surfaces of metal shall receive a mineral filler baked on and sanded between coats followed by a coat of primer. Primer shall be baked on in accordance with manufacturer's recommendations for developing maximum hardness and resistance to abrasion; paint dry film thickness not less than 1.25 mills.
 5. Primed surfaces shall be smooth and suitable to receive the finish coats.

2.06 FINAL FINISH

- A. Painted Doors: Provide a final painted finish conforming to Section 09900 - PAINTING. Color shall be as approved by the Engineer.
- B. Where indicated on Drawings, one side of type F security door shall have 20 mm thick pad with viyle coat finish.

2.07 HARDWARE PREPARATION

- A. General: Hollow metal doors and pressed metal frames shall be prepared at the manufacturer's plant for all hardware in accordance with templates furnished and shall be drilled and tapped to receive hardware as indicated on the hardware templates. Preparation shall conform to the requirements of ANSI A115.
- B. Mortised and concealed hardware: Mortise, reinforce, drill and tap for mortised and concealed hardware.
- C. Locations: Locate hardware as shown on the drawings and conform to standards established by the National Builders Hardware Association, and ANSI standards as applicable.

3. PART 3 - EXECUTION

3.01 INSPECTION

- A. Examine the substrates and the conditions under which hollow metal doors and frames shall be installed and correct any unsatisfactory conditions.
- B. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

3.02 INSTALLATION

- A. General: Install metal doors, frames, and accessories in accordance with final shop drawings and manufacturer's data, and as specified in this section.
- B. Placing Frames: Shall comply with provisions of SDI-105 (Recommended Erection Instructions For Steel Frames), unless otherwise indicated.
- C. Door Installation: Fit hollow metal doors accurately in frames, within clearances specified in SDI-100.
- D. Finish Hardware: Conform to Section 08710 - FINISH HARDWARE.

3.03 ADJUST AND CLEAN

- A. Prime Coat Touch-Up: Immediately after erection, sand smooth any rusted or damaged areas of prime coat and apply touch-up of compatible air-drying primer.
- B. Protection Removal: Immediately prior to final inspection, remove protective plastic wrappings from prefinished doors.
- C. Final Adjustments: Check and readjust operating finish hardware items

leaving steel doors and frames undamaged and in complete and proper operating condition.

- D. Finish Painting: Conform to Section 09900 - PAINTING.

END OF SECTION

SECTION 08100

HOLLOW METAL DOORS AND FRAMES

1. PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Architectural and security hollow metal doors and frames as shown on the Drawings and as specified herein.

1.02 REFERENCES

A. ASTM - American Society for Testing and Materials

ASTM A 36 Structural steel

ASTM A 164 Electro-deposited coating of Zinc on Steel

ASTM A 307 Carbon Steel externally and Internally threaded
Standard Fasteners

ASTM A 366 Steel sheets, Carbon, cold-Rolled Commercial Quality

ASTM A 525 General Requirement for Steel Sheet, Zinc-Coated
(Galvanized) by the Hot Dip Process

ASTM A 526 Steel Sheet, Zinc-Coated (Galvanized) by the Hot Dip
Process, Commercial Quality

ASTM A 569 Steel Carbon (0.15 Maximum Percent) Hot-Rolled sheet
and Strip, Commercial Quality

ASTM E 90 Laboratory Measurement of Airborne Sound
Transmission Loss of Building Partitions

ASTM F 1450 Standard Test Methods for Hollow Metal
Swinging Door Assemblies for Detention Facilities

ASTM F 1577 Standard Test Methods for Detention Locks for
Swinging Doors

B. FS - Federal Specification

FS-S-325 Shield Expansion, Nail Expansion and Nail Drive Screw
(Devices, Anchoring, Masonry)

C. ANSI - American National Standard Institute

A.115 Specifications for Door and Frame Preparation for
Hardware

D. SDI - Steel Door Institute

SDI 100 Standard Steel Doors and Frames

E. NFPA - National Fire Protection Association

NFPA 80 Fire Doors and Windows

F. NAAMM – National Association of Architectural Metal Manufacturer

HMMA 863 Guide Specifications for Detention Security
Hollow Metal Doors and Frames.

1.03 SUBMITTALS

- A. Product Data: Submit manufacturer's specifications for fabrication and installation, including data substantiation that products comply with requirements.
- B. Shop Drawings: Submit for fabrication and installation of metal doors and frames. Include details of each frame type, elevations of door design types, conditions at openings, details of construction, location and installation requirements of finish hardware and reinforcements, and details of joints and connections. Show anchorage and details of joints and connections. Show anchorage and accessory items. Provide schedule of doors and frames using same reference numbers for details and openings as shown on Drawings.
- C. Samples
 - 1. Submit 300 mm x 300 mm section sample of door showing internal construction, edge detail and reinforcement for butts for the Engineer review and approval.
 - 2. Submit 300 mm x 300 mm L-section sample of frame showing corner detail and 300 mm long samples of removable stop for the Engineer review and approval.

1.04 TRANSPORTATION, HANDLING AND STORAGE

- A. Deliver, store and handle hollow metal work in a manner to prevent damage and deterioration.
- B. Provide packaging such as cardboard or other containers, separators, banding, spreaders and paper wrappings to protect hollow metal items.
- C. Store doors and frames upright, in a protected dry covered area, at least 100 mm or more above ground or floor and at least 6 mm between individual pieces.
- D. Doors and frames are to have a metal tag with the door number thereon.

1.05 WARRANTY

- A. Submit a written 2 years guarantee, starting from substantial handover of the project, for all items specified under this Section, signed by manufacturer and the contractor, against all the defects, including bowing, and twisting.

1.06 QUALITY ASSURANCE

- A. General: Unless otherwise specified, provide doors and frames complying with the Steel Door Institute Specifications - Standard Steel Doors and Frames (ANSI/SDI- 100).
- B. Fire-Rated Door Assemblies: Provide doors and frames complying with NFPA 80 or ASTM E 152 and which are labeled and listed by UL, FM or other testing agency acceptable to the Engineer.
- C. Manufacturer: Provide doors and frames from a single manufacturer approved by the Engineer.

2. PART 2 - PRODUCTS

2.01 MATERIALS

- A. Hot-Rolled Steel Sheets and Strip: Commercial quality carbon steel, pickled and oiled, complying with ASTM A 569 and ASTM A 568.
- B. Cold-Rolled Steel Sheets: Commercial quality carbon steel, complying with ASTM A 366 and ASTM A 568.
- C. Galvanized Steel Sheets: Zinc-coated carbon steel sheets of commercial quality, complying with ASTM A 526 with ASTM A 252 G-60 zinc-coating, mill phosphatized.
- D. Reinforcement Steel: ASTM A 36.
- E. Core Material: Manufacturer's standard sound-deadening and heat-retarding mineral fiberglass insulating material.
- F. Supports and Anchors: Fabricated of 1.25 mm thick, galvanized sheet steel.
- G. Inserts, Bolts and Fasteners: Manufacturer's standard units, except hot-dip galvanize items to be built into exterior walls, complying with ASTM A 153, Class C or D as applicable.
- H. Shop Applied Paint: Rust-inhibitive enamel or paint, either air-drying or baking, suitable as a base for specified finish paints. Finish painting shall comply with the requirements of Section 09900 - PAINTING.

2.02 FABRICATION - GENERAL

- A. Fabricate metal door and frame units to be rigid, neat in appearance and free from defects (warp or buckle). Wherever practicable, fit and assemble units in manufacturer's plant. Clearly identify work that cannot be permanently factory-assembled before shipment, to assure proper assembly at project site.
- B. Fabricate exposed faces of doors and panels, including stiles and rails of non-flush units, from only cold-rolled steel.
- C. Fabricate frames, concealed stiffeners, reinforcement, edge channels, louvers and moldings from either cold- rolled or hot-rolled steel.
- D. Fabricate exterior doors, panels, and frames from galvanized sheet steel. Close top and bottom edges of exterior doors as an integral part of the door construction or by addition of inverted steel channels.
- E. Exposed Fasteners: Unless otherwise indicated, provide countersunk flat heads for exposed screws and bolts.
- F. Finish Hardware Preparation
 - 1. Prepare doors and frames to receive mortised and concealed finish hardware in accordance with Hardware Schedule and templates provided by hardware supplier. Comply with applicable requirements of ANSI A115 series specifications for door and frame preparation for hardware.
 - 2. Reinforce doors and frames to receive surface- applied hardware. Drilling and tapping for surface-applied finish hardware may be done at project site.
 - 3. Locate finish hardware as shown on final shop drawings or, if not shown, in accordance with Recommended Locations for Builder's Hardware, Published by Door and Hardware Institute.
- G. Shop Painting - Primer
 - 1. Clean, treat, and paint exposed surfaces of steel door and frame units, including galvanized surfaces.
 - 2. Clean steel surfaces of mill scale, rust, oil, grease, dirt, and other foreign materials before application of paint.
 - 3. Apply shop coat of prime paint of even consistency to provide a uniformly finished surface ready to receive finish paint.

2.03 PRESSED METAL FRAMES

- A. General: Provide continuous type pressed metal frames, including glazing stops and reinforcement, of various profiles to suit conditions detailed on the drawings and be constructed of new prime quality, hot or cold-rolled

sheet steel. Exterior frames shall be fabricated from zinc-coated sheet chemically treated after fabrication for optimum paint adhesion.

- B. Materials: Provide pressed metal frame of the following minimum thickness:
1. Exterior Frames: 1.9 mm thick.
 2. Interior Frames: 1.6 mm thick for openings that are 1 m wide or less and 1.9 mm thick for openings wider than 1 m.
 3. Exterior frames shall be provided with a weather striping, 2 mm thick.
 4. Wall Anchors: Same thickness and material as frame.
 5. Frame Splines: Same thickness and material as frames.
 6. Hinge Reinforcement: 250 x 40 x 5 mm, unless recommended otherwise by the manufacturer.
 7. Strike Reinforcement: 100 x 40 x 5 mm unless recommended otherwise by the manufacturer.
 8. Closer and Holder Reinforcement: 5 mm by the required length and width.
- C. Frames: Provide frames that have joints die-mitered with integral tabs for reinforcement and interlocking of the jambs to head. Frames shall be knockdown or equivalent, with self aligning tabs and slots for securely locked corners.
- D. Security Frames: Security metal frames indicated as security grade on drawings shall be standard heavy duty product produced by single manufacturer specialist in this production range. Security grade frame manufacturer and materials shall be subject to the Engineer approval.

Security metal frames shall be manufactured of heavy gauge steel sheets (12 gauge minimum) with additional reinforcing stiffeners and shall be with smooth edges and without any exposed removable parts. Security metal frames steel sheets shall be cold-rolled steel sheets conforming to ASTM A 366 or hot-rolled steel sheets conforming to ASTM A 569, steel sheets shall have zinc coating conforming to ASTM A 653.

Frames shall be welded units of the sizes and types shown on Drawings and shall comply with National Association of Architectural Metal Manufacturer Specifications - Guide Specifications for Detention Security Hollow Metal Doors and Frames -(HMMA 863), and shall be tested according with ASTM F 1450 and ASTM F 1577.

Security grade metal frames shall be installed as per the manufacturer

instructions and recommendations.

- E. Construction: The finished work shall be strong and of rigid construction neat in appearance and free from warp, wave and buckle. Molded members shall be clean cut, straight and true. Miters shall be well formed and in true alignment. Fastenings shall be concealed where practicable.
- F. Door Silencers: Except on weatherstripped frames, drill stops to receive 3 rubber silencers on strike jamb of single-swing frames and 4 silencers on heads of double-swing frames.
- G. Anchors
 - 1. Unless otherwise indicated on drawings, anchor frame in concrete and masonry walls by means of galvanized expansion shields and flat-head machine screws. Screw heads shall be counter-sunk in soffit of jamb. Machine screws shall be approved type, 9 mm diameter by minimum 75 mm long of zinc plated or dichromated steel with 9 mm diameter by minimum 44 mm long malleable iron or steel expansion shield. Reinforce jamb at each expansion screw location with 5 mm by 38 mm wide steel fitting into inside of stop and welded to backbends. Anchors shall be located not more than 150 mm from top and bottom of each jamb with intermediate anchors spaced at a maximum of 650 mm on center.
 - 2. Anchors for plaster partitions with truss stud framing shall be Z-clip type, to be secured to studs and welded to back of frames above each hinge reinforcement and just below the top hinge reinforcement. Anchors on the strike side shall occur directly opposite to those on the hinge side.
 - 3. Provide at least 4 anchors for each jamb for frames up to 2.28 m in jamb height; 5 anchors up to 2.40 m; and one additional anchor for each 0.6 m fraction thereof over 2.4 m jamb height.
- H. Bottoms of frames shall have not less than 2.8 mm thick welded-on floor clips punched for two 6.4 mm expansion bolts or shot pins. Return bends of frames shall be flanged.
- I. Temporary channel or angle spreaders shall be tack-welded to bottom of frames to prevent distortion during shipment and storage and shall hold the frames in proper position until adjacent construction has been completed.

2.04 HOLLOW METAL DOORS

A. Door Types

- 1. Interior doors: Fabricate interior hollow metal doors of 2 outer sheets, 1.2 mm thick cold rolled stretcher-level sheet steel, free from rust, scale, pits and surface defects. Unless

otherwise indicated on Drawings, hollow metal door thickness shall be 44mm.

2. Exterior doors: Fabricate exterior hollow metal doors of 2 outer sheets, 1.6 mm thick zinc-coated bonderized sheet steel. Provide exterior doors with spring tension type (aluminum or corrosion resisting steel) or integral elastomeric type (synthetic rubber, vinyl or neoprene) standard weather stripping at doors in accordance with the manufacturer's instructions and as approved by the Engineer. Unless otherwise indicated on Drawings, hollow metal door thickness shall be 44mm.
3. Metal Louvered Doors: Shall be manufacture's standard product fabricated of 18 gauge cold-rolled sheet metal, free from rust, scale, pits and surface defects. Door thickness shall be 44 mm. Stile channels, stiffener channels and other construction members shall be of sizes as recommended by the manufacturer. All exposed joints or seams shall be fully welded, filled and ground smooth to the Engineer satisfaction.
4. Service Heavy-Duty Doors: Fabricate service doors using same sheet facing thickness as that for interior or exterior doors as per door location. Provide additional reinforcing stiffeners for the door construction.
5. Security Doors: Security metal doors indicated as security grade door on drawings shall be standard heavy duty products produced by single manufacturer specialist in this production range. Security grade door manufacturer and materials shall be subject to the Engineer approval.

Doors shall be manufactured of heavy gauge steel sheets 14 gauge minimum as per use function requirements with additional reinforcing stiffeners and shall be with smooth edges and without any exposed removable parts. Doors steel sheets shall be cold-rolled steel sheets conforming to ASTM A 366 or hot-rolled steel sheets conforming to ASTM A 569, steel sheets shall have zinc coating conforming to ASTM A 653.

Doors types, sizes and grades shall be as shown on Drawings.

Where required as indicated on door type schedule drawing, provide doors with pans for hands, food pass, speaker opening, metal shelf with metal support, security metal wire mesh and vision security glass panels of thickness indicated on Drawings.

Security door including frame shall be 220 Kg weight minimum and shall be installed by professional contractor recommended from the manufacturer. Security grade Doors shall be installed as per the manufacturer instructions and recommendations.

Security metal doors shall comply with National Association of Architectural Metal Manufacturer Specifications - Guide Specifications for Detention Security Hollow Metal Doors and Frames -(HMMA 863), and shall be tested according with ASTM F 1450 and ASTM F 1577.

B. Door Construction

1. Doors are to have continuous internal reinforcing channels or z-shaped members, 1.5 mm thick steel, full height of door, spaced not more than 150 mm on center and spot welded to face sheets 75 mm on center. Doors with continuous truss inner core, full height and width, spot welded to face sheets at 75 mm on center both vertically and horizontally are also acceptable.
2. Provide 0.9 mm thick stile channels and 1.9 mm thick horizontal stiffener channels at top and bottom of doors welded to face sheets.
3. Fill hollow portions of doors shall be filled completely with expanded polyurethane, mineral fiberglass or rock wool or an approved equal filler.
4. Exposed joints shall be fully welded, filled and ground smooth.
5. Interlocking joints or seams are not approved on faces or edges.
6. Provide single swing doors with not more than 3 mm clearance at jambs and heads and not more than 6 mm clearance at meeting edges of pair of doors (3 mm on fire rated doors).
7. Doors shall have a 3 mm in 50 mm bevel on the strike side.
8. Where required as indicated on door type schedule drawing, provide doors with grills and vision glass panels of thickness indicated on Drawings.

C. Heads and jambs of doors shall be flush constructed unless otherwise shown. Fire rated door pairs shall be provided with astragal intumescent protection strip unless otherwise shown.

D. Undercutting: Undercut doors a maximum of 19 mm at bottom except toilet doors which shall be undercut a minimum of 30 mm, unless directed otherwise by the Engineer and unless otherwise shown in drawings.

E. Reinforcement: Provide reinforcement for finish hardware as follows:

1. Reinforcement for butts shall be not less than 5 mm thick by 230 mm long and 6 mm narrower than the thickness of the door.

2. Reinforcing plates for closers, holders, and stops shall be not less than 5 mm thick and by template requirements as to length and width.
 3. Reinforcement for locks and escutcheons shall be not less than 1.9 mm thick steel, with spring leaf contacts for lock cases.
 4. Reinforcement for exit devices and mortised or surface applied hardware shall be not less than 2.6 mm thick and by template requirements as to length and width.
- F. Tolerances: provide door panels that are free from buckles, twists or other imperfections. Do not use panels having a buckle exceeding 1.5 mm, as determined by a straight edge applied to the face of the panel.

2.05 SHOP FINISH

- A. Carry out shop finishing of metal doors and frames as follows:
1. Fill door edges with mineral filler to conceal seams.
 2. Chemically treat non galvanized, non bonderized metal surfaces with a phosphate compound to assure maximum paint adherence.
 3. Thoroughly clean all metal surfaces of all rust, scale, grease, rough spots and other foreign matter which may prevent proper paint adhesion.
 4. Apply dip or spray coat of rust-inhibitive metallic oxide zinc chromate or synthetic resin primer on all surfaces of frames and on all exposed surfaces of doors and panels. Exposed surfaces of metal shall receive a mineral filler baked on and sanded between coats followed by a coat of primer. Primer shall be baked on in accordance with manufacturer's recommendations for developing maximum hardness and resistance to abrasion; paint dry film thickness not less than 1.25 mills.
 5. Primed surfaces shall be smooth and suitable to receive the finish coats.

2.06 FINAL FINISH

- A. Painted Doors: Provide a final painted finish conforming to Section 09900 - PAINTING. Color shall be as approved by the Engineer.
- B. Where indicated on Drawings, one side of type F security door shall have 20 mm thick pad with viyle coat finish.

2.07 HARDWARE PREPARATION

- A. General: Hollow metal doors and pressed metal frames shall be prepared

at the manufacturer's plant for all hardware in accordance with templates furnished and shall be drilled and tapped to receive hardware as indicated on the hardware templates. Preparation shall conform to the requirements of ANSI A115.

- B. Mortised and concealed hardware: Mortise, reinforce, drill and tap for mortised and concealed hardware.
- C. Locations: Locate hardware as shown on the drawings and conform to standards established by the National Builders Hardware Association, and ANSI standards as applicable.

3. PART 3 - EXECUTION

3.01 INSPECTION

- A. Examine the substrates and the conditions under which hollow metal doors and frames shall be installed and correct any unsatisfactory conditions.
- B. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

3.02 INSTALLATION

- A. General: Install metal doors, frames, and accessories in accordance with final shop drawings and manufacturer's data, and as specified in this section.
- B. Placing Frames: Shall comply with provisions of SDI-105 (Recommended Erection Instructions For Steel Frames), unless otherwise indicated.
- C. Door Installation: Fit hollow metal doors accurately in frames, within clearances specified in SDI-100.
- D. Finish Hardware: Conform to Section 08710 - FINISH HARDWARE.

3.03 ADJUST AND CLEAN

- A. Prime Coat Touch-Up: Immediately after erection, sand smooth any rusted or damaged areas of prime coat and apply touch-up of compatible air-drying primer.
- B. Protection Removal: Immediately prior to final inspection, remove protective plastic wrappings from prefinished doors.
- C. Final Adjustments: Check and readjust operating finish hardware items leaving steel doors and frames undamaged and in complete and proper operating condition.

D. Finish Painting: Conform to Section 09900 - PAINTING.

END OF SECTION

SECTION 08210

WOOD DOORS AND FRAMES

1. PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Wood doors and frames as shown on the Drawings and as specified in this section .

1.02 REFERENCES

- A. AWI - Architectural Woodwork Institute:

AWI Architectural Woodwork Quality Standard Guide
Specification and Certification Program

- B. NWMA - National Woodwork Manufacturers Association:

IS.1 - Industry Standard for Flush Doors

- C. WIC - Woodwork Institute of California:

WIC Manual of Millwork

- D. ASTM - American Society of Testing and Materials:

ASTM E 152 Fire Test of Door Assemblies

- E. NEMA - National Electrical Manufacturer's Association:

LD 3 - High Pressure Decorative Laminates

- F. NFPA - National Fire Protection Association:

NFPA 80 - Fire doors and Windows

1.03 SUBMITTALS

- A. Product Data: Submit door manufacturer's product data for each type of wood door, including details of core and edge construction, unless otherwise indicated.
- B. Samples: Submit samples of door faces representing typical range of color and grain, strips of solid wood of species to be used for exposed edges, trim and other solid wood components.

1.04 TRANSPORTATION, HANDLING AND STORAGE

- A. Protect wood doors during transit, storage and handling to prevent damage, soiling and deterioration. Comply with requirements of referenced ANSI standards and recommendations of door manufacturer.
- B. Identify each door with individual opening numbers which correlate with

designation system used on shop drawings for doors, frames and hardware, using temporary, removable or concealed markings.

1.05 WARRANTY

- A. Door Manufacturer's Warranty: Submit two copies of written warranty in door manufacturer's standard form signed by the Manufacturer, Installer and Contractor, agreeing to repair or replace defective doors which have warped (bow, cup or twist) or which shows photographing of core construction below in face veneers, or do not conform to tolerance limitations of NWMA and AWI.
- B. The warranty shall also include refinishing and reinstallation which may be required due to repair or replacement of defective doors where defect was not apparent prior to hanging.
- C. Warranty shall be valid for a period of 2 years from the time of substantial completion.

2. PART 2 - PRODUCTS

2.01 WOOD DOORS - GENERAL

- A. Doors shall be fabricated meeting the applicable requirements of the quality standard of the Architectural Woodwork Institute.
- B. Door Size: Width, height and design shall be as shown on Drawings. Door shall be 44 mm thick, unless otherwise required by manufacturer or indicated on Drawings.
- C. Tolerances: Size, squareness and warp tolerances shall be in accordance with NWMA 1.S.1.
- D. Hardware: Conform to Section 08710 - DOOR HARDWARE.
- E. Prefit and premachine wood doors at factory complying with tolerance requirements of AWI for prefitting. Machine doors for hardware requiring cutting of doors. Comply with final hardware schedule and door frame shop drawings and with hardware templates and other essential information required to ensure proper fit of doors and hardware.
- F. Wood used for doors and frames shall be approved by the Engineer as well as the door construction and design.

2.02 SOLID WOOD PANEL DOORS

- A. Doors shall be constructed of best quality hardwood with a minimum thickness of 44 mm, unless otherwise required by door manufacturer or indicated on Drawings.

1. Type of wood shall be teak for external doors and oak for internal doors or as indicated on Drawings.
 2. Stiles, top and bottom rails, decorative panels and moldings, transoms, sidelights, shall be of sizes and patterns as shown on Drawings and as approved by the Engineer.
- B. Door components shall be assembled using tongued and grooved connections as well as adhesive Type I and in accordance with the fabrication procedures mentioned below.
1. Where indicated on Drawings, Submit various decorative designs for panels for the Engineer selection and approval.

2.03 SOLID CORE FLUSH WOOD DOORS

- A. Shall be constructed of solid wood inside stiles and rails with blocking or mineral fill, bonded together using type I adhesive. Door shall have a face veneer, 3 mm thick premium grade oak wood specie. Lumber for stiles and rails shall be AEI premium grade.

2.04 HOLLOW CORE FLUSH DOORS

- A. Doors shall be constructed of at least 50% solid wood blocks bonded together with water resistant adhesive notched into stiles and a metal or timber frame. Lumber for stiles and rails shall be softwood AWI premium grade. Moisture content of wood shall be satisfactory for intended use. Provide 3-ply oak wood face veneers, 3 mm thick, premium grade. Doors shall be sound, rigid and free from defects and warp. All edges shall be aligned and smooth.

2.05 DOOR FRAMES

- A. Door Frame Type: As indicated on Drawings and in accordance with the following requirements:
1. Solid Wood Frames:
 - a. Type of Wood: Use rigid, square and uniform, best quality solid hardwood, architectural grade, clear all heart. Type of wood shall be as indicated on Drawings.
 - b. Wood used shall be of a species listed as suitable for doors frames and shall match with type specified for the related wood door.
 - c. Frame Sizes, Rebates and Shapes: As shown on Drawings and as approved by the Engineer. Frame rebates shall be 13 mm minimum depth for the internal doors and 19 mm for the external doors. Frames shall have wood architraves as shown

on Drawings.

2. Hollow Steel Doors Frames: Manufacturer standard steel doors frames complying with the requirements specified in Section 08100 - HOLLOW METAL DOORS AND FRAMES.

2.06 FABRICATION

- A. Openings: Where indicated, cut and trim openings through doors and panels complying with the applicable requirements of referenced standards for the kind of doors required.
- B. Exterior Doors: Treat exterior doors at factory with water repellent after manufacturing has been completed.
- C. Assembly: Assemble solid panelled doors and frames using be tongued and grooved connections with Type I waterproof adhesive.
- D. Adhesives: Assemble doors using Type I waterproof adhesives.
- E. Factory-Finishing: Provide manufacturer's standard finish to match approved sample.

2.07 FINISH

- A. Doors and Frames Finish: As indicated on Drawings and in accordance with the requirements of Section 09900 - PAINTING.

3. PART 3 - EXECUTION

3.01 INSTALLATION

- A. Each door unit shall be installed in accordance with the manufacturer's instructions including handling and storage recommendations.
- B. Doors shall be fitted to the following tolerances:
 1. 3.18 mm on each vertical side and top.
 2. 13 mm on bottom, except when fitted hardware requires otherwise.
 3. Bevel non-rated doors 3.18 mm in 50 mm at lock and hinge edges.
- C. Install finish hardware to the templates provided. Fit to frames and machine for hardware to whatever extent not previously worked at factory as required for fit and uniform clearance at each edge.
- D. Restore finish on edges of shop-finished doors before installation, if fitting

or machining is required at the job site.

3.02 ADJUST AND CLEAN

- A. Operation: Rehang or replace doors which do not swing or operate freely, as directed by the Engineer.
- B. Finished Doors: Refinish or replace doors damaged during installation as directed by the Engineer.
- C. Institute protective measures as recommended and accepted by door manufacturer to assure that wood doors will be without damage or deterioration at time of substantial completion.

END OF SECTION

SECTION 08520

ALUMINUM WINDOWS

1. PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Aluminum windows as shown on Drawings and specified in this section.

1.02 REFERENCES

A. AAMA- American Architectural Manufacturer'S Association

AAMA 101 Aluminum Prime windows and Sliding Glass Doors

AAMA 603.8 Pigmented Organic Coating on Extruded Aluminum

AAMA 605.2 High Performance Organic Coatings on Architectural aluminum Extrusions and Panels

AAMA 606.1 Color Anodic Finishes for Architectural Aluminum

AAMA 607.1 Clear Anodic Finishes for Architectural Aluminum

AAMA 701.2 Voluntary Specification for Pile Weather Stripping

B. AA - Aluminum Association

Aluminum Association Designation System for Aluminum Finishes

C. ANSI - American National Standards Institute:

A134.1 Specification for Aluminum Prime windows.

D. ASTM - American Society of Testing and Materials:

ASTM B 136 Stain Resistance of Anodic Coatings on Aluminum

ASTM B 137 Weight of Coatings on Anodically Coated Aluminum

ASTM B 209 Aluminum and Aluminum-Alloy Sheet and Plate

ASTM B 211 Aluminum and Aluminum-Alloy Bars, Rods and Wire

ASTM B 221 Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes and Tubes

ASTM B 244 Thickness of Anodic Coatings on Aluminum with Eddy-Current Instrument

ASTM D 2287 Non-Rigid Vinyl Chloride Polymer and Copolymer Molding and Extrusion Compounds.

ASTM D 3656 Insect Screening and Louver Cloth Woven From Vinyl-Coated Glass fiber Yarn

ASTM E 283 Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors

ASTM E 330 Structural Performance of Exterior Windows, Curtain Walls and Doors Under the Influence of Wind Loads.

ASTM E 331 Water Penetration of Exterior Windows, Curtain Walls and Doors by Uniform Static Pressure Difference Loads

ASTM E 547 Water Penetration of Exterior Windows, Curtain Walls and Doors by Cyclic Static Air Pressure Difference Loads

ASTM F 468 Nonferrous Bolts, Hex Cap Screws, and Studs for General Use

E. DIN - Deutsches Institut fuer Normung

DIN 4108 Heat Insulation in Buildings

DIN 18055 Windows; Air Permeability of Joints, Water Tightness and Mechanical Strain

F. AWS - American Welding Society:

D1.1 Structural Welding Code, Steel

D1.2 Structural Welding Code, Aluminum

1.03 SUBMITTALS

A. Product Data: Submit manufacturer's specifications, standard details, and installation recommendations for components of aluminum windows required for project, including data that products have been tested and comply with performance requirements.

B. Certification: Submit statement certified by registered Structural engineer that systems including glass will withstand specified wind-loads.

C. Samples: Submit samples of each type and color of aluminum finish, on 300 mm long sections of extrusions or formed shapes.

1.04 TRANSPORTATION, HANDLING AND STORAGE

A. Deliver aluminum window to site in packages or containers; labeled for identification with the manufacturer's name, brand and contents. Store aluminum window material in weather tight and dry storage facility. Protect from damage from handling, weather and construction operations before, during and after installation.

1.05 WARRANTY

- A. Submit 2 copies of written guarantee signed by the manufacturer, installer and contractor, agreeing to replace aluminum window units which fail in material or workmanship within 2 years of date of substantial handing over.

1.06 QUALITY ASSURANCE

- A. Standards: Comply with applicable provisions of the Metal Curtain Wall, Window, Storefront and Entrance Guide Specifications Manual - AAMA.
- B. General: Provide aluminum window units that comply with performance requirements specified, as demonstrated by testing manufacturer's corresponding stock systems according to test methods indicated. Type of windows shall be as shown on the drawings.
- C. Testing: Test each type and size of required window unit through a recognized independent testing laboratory or agency approved by the Engineer, in accordance with ASTM E 330 for structural performance, ASTM E 283 for air infiltration, and ASTM E 331 and ASTM E 547 for water penetration. Provide certified test results. Sizes of test units for the air infiltration, water resistance, and structural performance shall conform to the AAMA Guide Specification GS-001 - Chart A requirements. Tested units shall be glazed, completely assembled, and constructed in accordance with requirements indicated. Perform tests on units with window sash and ventilators closed and locked. Materials and workmanship used in test units shall be identical to those proposed for the project. Use of nonrepresentative measures or techniques is prohibited.
- D. Design Requirements: Comply with structural performance, air infiltration, and water penetration requirements indicated in AAMA 101 for type, grade and performance class of window units required.
 - 1. In addition to AAMA design standards, component parts and completed window assemblies shall be designed, fabricated and installed to withstand design pressure of minimum 98 kg/m², for wind loads normal to wall, acting both inward and outward.
 - 2. Uniform Load Deflection: No window member (glazed) shall deflect more than 1/175 of its span at the specified design load when tested in accordance with ASTM E 330 at a static air pressure difference of at least 98 kg/m², with ventilators closed and locked and the pressure applied first on one side of the unit then on the other.
 - 3. Air infiltration rate of aluminum windows shall not be more than 0.30 cfm per ft of operable sash joint for inward test pressure of 30 kg/m², when tested in accordance ASTM E 283.
 - 4. Water Penetration: There shall be no water penetration, as defined in ASTM E 331, when tested in accordance with ASTM E 331 at an

inward test pressure of 39 kg/m².

5. Forced-Entry Resistance: Provide window units having a Performance Level 10 when tested in accordance with ASTM F 588.
- E. Manufacturer and Installer Qualifications: Engage on experienced manufacturer and installer who has minimum 5 years experience of manufacturing and installing aluminum windows similar in design and finish to those required for the project and which has resulted in construction with a record of successful in-service performance. Manufacturer and installer shall be subject to approval of the Engineer.
- F. Single Source Responsibility: Provide aluminum window units from one source and produced by a single manufacturer.
- G. Field Measurements: Check actual window openings by accurate field measurements before fabrication. Show recorded measurements on final shop drawings. Coordinate fabrication schedule with construction progress to avoid delay.

2. PART 2 - PRODUCTS

2.01 MATERIALS AND ACCESSORIES

A. General:

1. Provide manufacturer's standard windows complete with members, hardware, weatherstripping, glazing beads, setting blocks, and glazing wedges.
2. Exterior windows and sliders shall have dead locks. Sliders shall have stainless steel V-channel over the slider track with nylon roller.
3. Operable exterior sections of sliding windows shall have aluminum insect screens.

B. Aluminum members:

1. Extrusions of bars, rods and tubes: 6063-T6 alloy conforming to ASTM B 221.
2. Sheets and plates: 5005-H14 alloy conforming to ASTM B 209.
3. Window frames and sashes shall be manufacturer standard systems of extrusions not less than 3 mm thick.

C. Fasteners: Aluminum, or non-magnetic stainless steel, or a non-corrosive material, compatible with the aluminum components and warranted by manufacturer.

1. Do not use exposed fasteners except where unavoidable for application of hardware. Match finish of adjoining metal.
 2. Provide flat-head machine screws for exposed fasteners.
- D. Brackets and Reinforcements: Manufacturer standard high-strength aluminum units where feasible; otherwise, non-magnetic stainless steel or hot-dip galvanized complying with ASTM A 386.
- E. Concrete/Masonry Inserts: Cast iron, malleable iron, or hot-dip galvanized steel conforming to ASTM A 386.
- F. Bituminous Coatings: Cold-applied asphalt mastic complying with SSPC - Paint 12, compounded for 20 mil thickness per coat.
- G. Sealants: Aluminum frames shall be sealed using a sealant of a type conforming to Section 07900 - SEALANTS, and a color matching with the aluminum profiles.
- H. Glass: Conform to Section 08800 - GLAZING. Type of glazing shall be as shown on the Drawings.
- I. Weatherstripping: For horizontal sliding or double-wing window units provide sliding type woven pile weatherstripping of wood, polypropylene or nylon pile and resin-impregnated backing fabric, and aluminum backing strip complying with AAMA 701.2. For other types of windows provide compression-type weatherstripping, compressible molded expanded EPDM or neoprene weatherstripping gaskets in accordance with ASTM C 509.
- J. Glazing Gasket: Manufacturer's standard vinyl glazing gasket.
- K. Hardware: Provide manufacturers standard hardware fabricated from aluminum or stainless steel compatible with aluminum and of sufficient strength to perform and function as intended.

2.02 FINISHES

- A. Exposed aluminum surfaces shall have the manufacturer's standard finish, anodized or powder-coated as indicated on Drawings and in accordance with the following:
1. Anodized Finish: Conform to AA C22A42; 22 micron thick; with shop-applied protective coating of clear acrylic lacquer or any coating in accordance with AAMA 602.2, 0.5 mil dry film thickness, over anodized finish. Color shall be as approved by the Engineer.
 2. Powder Coated Finish: 60 - 80 micron thick. Color shall be approved by the Engineer.

2.03 FABRICATION

- A. General: Provide manufacturer's standard fabrication and accessories which comply with indicated standards and are reglazable without dismantling of sash framing, except to extent more specific or more stringent requirements are indicated. Include complete system for assembly of components and anchorage of window units, and prepare sash for glazing except where pre-glazing at factory is indicated. Fabrication and installation of aluminum windows shall be executed by an approved specialized firm having at least 5 years experience of successfully completed projects.
- B. Sizes and Profiles: Required sizes for window units and profile requirements are shown on the drawings. Details, where shown, are based upon standard details by one or more manufacturers. It is intended that similar details by other manufacturers shall be acceptable, provided they comply with size requirements, minimum/maximum profile requirements and performance standards as shown or specified.
- C. Pre-glazed Fabrication: Pre-glaze window units at factory where possible and practical for applications indicated. Comply with requirements of Section 08800 - GLAZING in addition to requirements of ANSI/AAMA 302.9.
- D. Provide weep-holes and internal passages to drain infiltrating water and condensation to exterior.
- E. Weatherstripping: Provide compression-type weather-stripping at perimeter of each operating sash where sliding-type is not appropriate. Provide sliding-type weatherstripping at all locations where sash rails slide horizontally or vertically along frame of units.
- F. Provide mullions and cover plates as shown matching window units, and complete with anchors for support and installation. Allow for erection, tolerances and provide for movements of window units due to thermal expansion and building deflections.

3. PART 3 - EXECUTION

3.01 INSPECTION

- A. Window openings shall conform with dimensions and tolerances shown on the drawings.
- B. Examine substrates, adjoining construction, and the conditions under which work is to be installed. Installation shall not proceed until unsatisfactory conditions are corrected.

3.02 INSTALLATION

- A. Comply with the manufacturer's written instructions for installation of units and other components.
- B. Units shall be set plumb, level and true to line, without warp or rack of frames.
- C. Frames shall be anchored solidly to surrounding construction to prevent distortion or misalignment.
- D. Apply protective coating to separate aluminum from galvanically incompatible materials, including concrete and steel casting as recommended by aluminum manufacturer.

3.03 CLEANING AND PROTECTION

- A. Upon completion of installation of aluminum windows, clean exposed metal and glass surfaces of excess sealants, dirt and other substances. Exercise care to avoid damage to protective coatings and finishes. Lubricate hardware.
- B. Protect the installed work until substantial completion and replace or replace the damaged work as required by the Engineer.

END OF SECTION

SECTION 08710

FINISH HARDWARE

1. PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Door hardware as shown on Drawings and as specified herein.
- B. Verify the accuracy of quantities, sizes, finish and proper hardware to be provided. Determine all details related to door locksets functions. Hardware not specifically listed for a particular opening shall be provided under this Section and shall be the same as hardware types and quality for similar opening elsewhere in the building or as directed by the Engineer.

1.02 REFERENCES

A. ANSI - American National Standards Institute

A156.1 - Butts and Hinges (BHMA 101)

A156.2 - Locks and Lock Trim (BHMA 601)

A156.3 - Exit Devices (BHMA 701)

A156.4 - Door Control Closers (BHMA 301)

A156.6 - Architectural Door Trim (BHMA 1001)

A156.13 - Mortise Locks and Latches (BHMA 621)

A156.16 - Auxiliary Hardware (BHMA 1201)

A156.18 - Materials and Finishes (BHMA 1301)

B. NFPA - National Fire Protection Association

NFPA 80 - Standard for Fire Doors and Windows

NFPA 101 - Code for Safety to Life from Fire in Buildings and Structures

C. UBC - Uniform Building Code

All Applicable Sections.

1.03 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data for each item of hardware. Include whatever information may be necessary to show compliance with the requirements and include installation and

maintenance of operating parts and finish instructions.

- B. Hardware Schedule: Submit final hardware schedule including coordination with doors, frames and related work to ensure proper size, thickness, hand, functions and finish of hardware. Submit separate detailed schedule showing the implementation of the Owner's final instruction on the keying of locks.
- C. Samples: Prior to submittal of hardware schedule and ordering of hardware, submit one sample of each type of exposed hardware unit, finished as required, and tagged with full description for the approval of the Engineer.

1.04 TRANSPORTATION, HANDLING AND STORAGE

- A. Deliver items of hardware to job site in Manufacturer's original new packing, complete with necessary appurtenances including screws, keys and instructions. Mark each individual container with manufacturer's name and catalog number as they appear in hardware schedule.
- B. Provide secure lock-up for hardware delivered to Project. Control handling and installation of hardware items which are not immediately replaceable, so that completion of work will not be delayed by hardware losses, both before and after installation.

1.05 WARRANTY

- A. Submit written guarantee signed by Manufacturer and Contractor, agreeing to replace hardware items which fail in material or workmanship within 2 years of the date of substantial handing over.

1.06 QUALITY ASSURANCE

- A. Manufacturers: Obtain each type of hardware from a single manufacturer to the greatest possible extent.
- B. Supplier: A recognized architectural hardware supplier with warehousing facilities, and has been providing hardware for similar Projects for a period of not less than 2 years and who has, or will employ an experienced architectural hardware consultant to be available, at reasonable times during work, for consultation about Project's hardware requirements to the Engineer as well as Contractor.

2. PART 2 - PRODUCTS

2.01 MATERIALS

- A. General:
 - 1. Hardware shall be of Grade 1, heavy-duty type, solid metal, entirely free from imperfections in manufacture and finish and shall be UL

Listed.

2. Finish of Hardware: Conform to BHMA coding. Finish shall be as shown on Drawings and in accordance with the following:
 - a. Stainless steel: Conform to the BHMA Code 629; polished (bright) finish, with no coating and complying with ANSI/BHMA A156.18.
 - b. Stainless steel: Conform to the BHMA Code 630; satin finish, complying with ANSI/BHMA A156.18.
 3. Provide matching finish for different components of the same hardware set.
 4. Provide hardware items of proper design for the use of doors and frames of thickness, profile, swing, security and similar requirements indicated and as necessary for proper installation and operation.
- B. Door Handles: Provide door handles of matching products, best quality, heavy duty, with finish and as indicated in drawings hardware schedule as approved by the Engineer.
- C. Door Knobs: Provide door knobs of matching products, best quality, heavy duty, with finish and as indicated in drawings hardware schedule as approved by the Engineer.
- D. Fasteners: Fabricated of stainless steel, head finish matching with the surface of hardware item. Furnish screws for installation, with each hardware item. Provide Phillips flat-head screws except as otherwise indicated. Finish exposed or partially exposed screws to match hardware finish or, if exposed in surfaces of other work, to match finish of such other work as closely as possible, including - prepared for paint - in surfaces to receive painted finish. Provide concealed fasteners for hardware units which are exposed when door is closed, except to extent no standard units of type specified are available with concealed fasteners.
- Furnish wood screws for all connections to wood doors, and machine screws for all connections to metal parts and assemblies.
- E. Hinges:
1. Butt hinges shall meet the requirements of ANSI A156.1 (BHMA 101). Hinges shall bear mark or trademark of manufacturer. Size of hinge shall be 100 x 100 mm, unless indicated otherwise on hardware schedule. Full mortise five knuckle hinges shall have flat button tips, square cornered and shall have stainless steel pins, non-removable pins for external doors. Number of hinges for each door type shall be in accordance with Hardware Schedule shown on Drawings.

2. Hinges shall have minimum leave thickness 4.76 mm for exterior and vestibule door as well as doors over 1000 mm wide, and 3.7 mm leave thickness for other doors of standard construction. Full mortise hinges with heavy duty ball bearing shall be used for external doors and full mortise hinges with standard ball bearing shall be for internal doors.
- F. Locksets and Latchsets: Conforming to ANSI A156.13 (BHMA 621), UL listed, shall be heavy duty series, Operational Grade 1, Security Grade 2, mortise and cylinder type as required, functions as indicated in hardware schedule and as shown on drawings. All locks shall be construction grandmasterkeyed. Electric locks, where required, shall have a solenoid integrated to lock mechanism which shall operate the lock function through a keypad or cardreader, and shall conform to UL 38G5. Keybads and cardreaders shall conform to Section 16780 - SECURITY SYSTEM.
1. Lock cylinders: Models selected shall conform to ANSI A156.5 (BHMA 1001), having a minimum of 6 pin tumblers. Lock cylinders be interchangeable cores with their keys. Lock cylinders shall be comply with grandmasterkeys system which prepared to open the different locks of the building. Lock cylinders shall be permanently inscribed with a number that identifies the key-change combination to the building lock manufacturer. Only manufacturer's name or trademark shall be visible after installation.
 2. Locksets and Latchsets: As shown on drawings, cylindrical or mortise types providing the lock functions as shown on drawings, minimum backset 70 mm with stainless steel, polished lever/knob handle and escutcheons, minimum thickness 1.25 mm. Knobs shall be spherical design. Latchbolt throw shall be 16 mm minimum except when lockset is used on pairs of doors where latchbolt throw minimum is 19 mm. For locksets with deadbolt function, minimum throw of deadbolt shall be 25 mm.
 3. Strikes: Shall be wrought box type, lips curved and returned to door frame or frame trim with minimum projection necessary for protection of frame and trim.
- G. Exit Devices (Panic Bolt): Exit devices shall meet the requirements of ANSI A156.3, Grade 1, UL listed and as indicated in hardware schedule.
- H. Flush Bolt: Type required shall be as indicated on the Hardware Schedule. Flushbolt location, aligned in edge of door with operating mechanism of top bolt centered 300 mm from top of door and bottom bolt centered 300 mm above bottom of door. For doors over 2100 mm in height bolt height shall not exceed 1800 mm from the floor.
- I. Door Closers: Unless otherwise indicated on the drawings, comply with ANSI A156.4, Grade 2, overhead surface-mounted type, function as required or as recommended by manufacturer. Sweep period of the closer shall be adjusted so that from an open position of 70 degrees, door will take at least 3 seconds to move to a point 75 mm from the latch, measured to the leading edge of the door. Closer shall have automatic

hold-open feature.

- J. Electro-Magnetic Holder: Electro-magnetic door holders shall be wall mounted type. In the event of power interruption the magnetic coil shall de-energize and release the door. Magnet shall be radial di-pole type with holding force in excess of 11.30 kg. Door holders shall conform to ANSI A 156.15.
- K. Kick Plates: Stainless steel, size as indicated in hardware schedule, conforming to ANSI A156.6, polished finish and matching door hardware set. Where required, provided with cuts for lock cylinders.
- L. Thresholds: Provide units not less than 100 mm wide complying with ANSI A156.6, extruded aluminum with minimum 3 mm wall thickness. Height of threshold shall conform to door cut.
- M. Door Stops: Conform to ANSI A156.16 (BHMA 1201) Grade 1. Provide floor or wall mounted door stop as approved by the Engineer.

2.02 KEYS AND KEYING

- A. Keys shall be permanently inscribed with a number that identifies the cylinder or lock manufacturer and the key symbol. Keys shall be appropriately tagged. Keys shall be provided as follows:
 - All Locks : 3 keys.
 - Master key for each building of the project buildings.
- B. Number of keys shall be provided as follows:
 - 1. Each Lock: 3 keys.
 - 2. Grandmaster key for each building: 6 grandmaster keys.
- C. Change-key Blanks: 50 to fit keyway of cylinders for all locks.
- D. Keying shall be in sets and sub-sets. Keys of any one set or subset shall not operate of any other set unless scheduled otherwise. Keys shall be packaged with core cylinders in sealed containers.
- E. Key-control symbols consist of letter suffix to hardware set numbers.
- F. Provide a key control system including envelopes, labels, tags with self-locking key clips receipt forms, 3-way visible card index, temporary markers, permanent markers, and proper size lockable metal cabinet for keys storage all as recommended by the system manufacturer and approved by the Engineer.

2.03 HARDWARE SCHEDULE

- A. As indicated on Drawings.

2.04 SECURITY GRADE HARDWARE:

- A. Any hardware item indicated as security grade hardware in drawings or in any other documents of the project documents shall be standard product, produced by single manufacturer specialist in this production range. Security grade hardware manufacturer and materials shall be subject to the Engineer approval.
- B. Security grade hardware shall be without exposed sharp edges or removable parts.
- C. Security grade hardware shall be installed by professional installer recommended from the manufacturer. Security grade hardware shall be installed as per the manufacturer instructions and recommendations.

3. PART 3 - EXECUTION

3.01 INSTALLATION OF HARDWARE

- A. General: Finish hardware items shall be installed in a neat, workmanlike manner according to the manufacturer's written recommendations, unless otherwise specified in this section.
- B. Fasteners: Suitable fastening devices shall be provided for installation of hardware items. Installation shall provide against shock and tampering. Exposed fastenings shall match contiguous materials and finish of hardware items and shall be inconspicuous. Where practicable finish flush with surrounding surfaces and fastenings shall be of materials compatible with contacting hardware surfaces.
- C. Final Adjustment: Immediately upon completion and acceptance of the project, make final adjustments in the finish hardware installation; remove construction core from cylinders and then open sealed containers in the presence of the Engineer and install proper core in cylinders, demonstrate to the Engineer that each item is in perfect working condition; perform intended function and that tagged keys operate respective locks. Correct items of hardware not acceptable to the Engineer by proper adjustment or replacement at no cost to the Owner. Deliver tagged keys upon acceptance of each core cylinder installation.
- D. Protection: Protect installed hardware from paint, stains, and blemishes until acceptance of the work.
- E. Location of Hardware on Hinged Doors: Locate in accordance with the Recommended locations for Builder's Hardware for Custom Steel Doors and Frames as published by the Door and Hardware Institute.

END OF SECTION

SECTION 08800

GLAZING

1. PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Glazing for doors and windows.
- B. Mirrors.
- C. Glazing materials and accessories.

1.02 REFERENCES

A. ASTM - American Society of Testing and Materials

ASTM C 920 - Elastomeric Joint Sealant

ASTM C 964 - Locking-Strip Gasket Glazing

ASTM C 1036 - Flat Glass

ASTM C 1048 - Heat-Treated Flat Glass

ASTM E 774 - Sealed Insulating Glass Units

B. FGMA - Flat Glass Marketing Association

Glazing Sealing Systems Manual

Glazing Manual

C. FS - Federal Specifications

DD-G-451 - Glass, Float or Plate, Sheet, Figured (Flat, for Glazing, Mirrors and other Uses)

DD-G-1403 - Glass, Plate (Float), Sheet, Figured, and Spandrel (Heat Strengthened and Fully Tempered)

DD-M-411 - Mirrors, Plate, Glass, Framed

D. ANSI - American National Standards Institute, Inc.

Z97.1 - Performance Specification and Methods of Test for Safety Glazing Material Used in Buildings

E. NFPA - National Fire Protection Association

Glazing Manual

1.03 SUBMITTALS

- A. Product Data: Submit manufacturers technical data for glazing material and fabricated glass product required, including installation and maintenance instructions.
- B. Samples: Submit 300 mm x 300 mm samples of each type of glass to be used.
- C. Certificates: Submit certificates from manufacturer attesting that glass and glazing materials furnished for the project comply with requirements.

1.04 TRANSPORTATION, HANDLING AND STORAGE

- A. Protect glass and glazing materials during delivery, storage and handling to comply with manufacturer's written directions and as required to prevent edge damage to glass, and damage to glass and glazing materials from effects of moisture including condensation, of temperature changes, of direct exposure to sun, and from other causes, including high altitude limitations for insulating glass.

1.05 WARRANTY

- A. Submit a written guarantee signed by Manufacturer and Installer of glazing for a period of 4 years from the date of substantial completion. The Guarantee shall cover the replacement of defective materials and workmanship as directed by the Engineer.

1.06 QUALITY ASSURANCE

- A. Glazing Standards: Comply with recommendations of Flat Glass Marketing Association (FGMA) - Glazing Manual and Sealant Manual except where more stringent requirements are indicated. Refer to those publications for definitions of glass and glazing terms not otherwise defined in this Section or other referenced standards.
- B. Safety Glazing Standard: Where safety glass is indicated, provide type of products which comply with ANSI Z97.1.
- C. Provide insulating glass units permanently marked either on spacers or at least one component pane of unit with appropriate certification label of inspecting and testing organizations.

1.07 PROJECT CONDITIONS

- A. Do not proceed with glazing when ambient and substrate temperature conditions are outside limits permitted by glazing material manufacturer or

when joint substrates are wet due to rain, frost, condensation or other cause.

- B. Install sealant at ambient and substrate temperatures permitted by sealant manufacturers.

2. PART 2 - PRODUCTS

2.01 GLASS PRODUCTS - GENERAL

- A. Primary Glass Standard: Provide primary glass which complies with ASTM C 1036 requirements, including those indicated by reference to type, class, quality, and if applicable, form, finish, mesh and pattern.
- B. Heat-Treated Glass Standard: Provide heat-treated glass which complies with ASTM C 1084 requirements, including those indicated by reference to condition, type, quality, class, and if applicable, form, finish, and pattern.
- C. Sizes: Fabricate glass to sizes required for glazing openings indicated, with edge clearances and tolerances complying with recommendations of glass manufacturer. Provide thicknesses indicated or, if not otherwise indicated, shall be as indicated in the standards and as recommended by glass manufacturer for application indicated, but not less than 6 mm thick for windows and 12 mm for doors (single glazing).

2.02 SECURITY GRADE GLAZING:

- 1. Glazing items indicated as security grade glazing on drawings shall be standard products produced by single manufacturer specialist in this production range. Security grade glazing system manufacturer and materials shall be subject to the Engineer approval. Security grade glazing system shall be without exposed removable parts and shall be suitable for the intended use.
- 2. Clear\Translucent Laminated Security Glass: Security glass shall be clear\translucent laminated multi-ply from two or more pieces of annealed or tempered glass as per location requirements to provide required security protection degree.
- 3. Security Double Glazed One Way Reflected Glass: Security double glazed one way reflected glass shall be of one side laminated multi-ply from two or more pieces of annealed or tempered glass and other side of one way reflected glass with 12 mm air spaces between both sides as per glass location requirements to provide the required security protection degree.
- 4. Laminated Bullet Resistant Security Glass: Shall be laminated multi-ply glass from two or more pieces of annealed or tempered glass as per location requirements to provide required security protection degree.

2.03 GLAZING

A. Tempered Float Glass:

1. Grade B (fully tempered), Style I (uncoated surfaces), Type I (transparent glass, flat), Class 1 (clear), quality q³ (glazing quality), minimum 6 mm thick for windows, 8 mm thick for doors, and 12 mm for fully glazed doors.
2. Provide tempered float glass for doors and windows indicated on Drawings to have single glazing.

B. Sealed Insulating Glass Units - Double Glazing:

1. Provide pre-assembled units consisting of sealed panes of glass enclosing a hermetically sealed dehydrated air space and complying with ASTM E 774 for performance classification indicated as well as with other requirements specified for glass characteristics, air space, sealing system, sealant, spacer material, corner design and desiccant. Units shall have thermal conductivity U-Value of 2.5 W/m²/K and an overall Shading Coefficient of 0.3. Spacer material shall be manufacturer's standard aluminum or stainless steel. Desiccant shall be either molecular sieve or silica gel or blend of both. Sealed insulated glass shall be 24 mm thick consisting of two 6 mm thick tempered glass panels separated by 12 mm air space, clear for the inside panel and tinted for the outside panels. Color shall be as approved by the Engineer.
2. Provide sealed insulating glass units for doors and windows indicated on Drawings to have double glazing.

C. Sealed Insulating Glass Units (with Louvers):

1. Panel Construction: Manufacturer standard insulated glazing panels, with extruded aluminum louvers double sealed within the glass. Sealed insulated glass shall consist of two 6 mm thick tempered glass panels separated by an air space, clear for the inside panel and tinted for the outside panels. Color shall be as approved by the Engineer.
2. Where indicated on Drawings, provide manually operated louvers via manufacturer standard sealed mechanism. Mechanism shall include pivots, racks and pinions all manufactured using UV stabilized materials to ensure dimensional stability. No exposed cords or strings shall be permitted. Magnetic systems shall not be acceptable.

2.04 MIRRORS

- A. Type I, Class I, Quality q², Clear float mirror, fully silvered electrically copper-plated, 6 mm thick, exposed edges ground and face corners cased, guaranteed against silver spoilage for 15 years.
- B. Size and location of mirrors shall be as indicated on Drawings.

2.05 GLAZING MATERIALS AND ACCESSORIES

- A. Glazing Gaskets: Dense elastomeric seal gaskets shall be continuous neoprene or polyvinyl chloride extrusions, of 50 Shore A durometer hardness plus or minus 5 complying with ASTM C 864.
- B. Lock-Strip Gaskets: Conform to ASTM C 542, neoprene extrusions of required size and shape. Frames fabricated with injection molded corners. Provide with separate lock (zipper) strips, Shore A durometer 10 points harder than gasket body.
- C. Setting Blocks: Neoprene, EPDM or silicone blocks as required for compatibility with glazing sealants, 80 to 90 Shore A durometer hardness.
- D. Spacers: Neoprene blocks, 40 to 50 Shore A durometer hardness, self-adhesive on one face only; compatible with sealant used. Use EPDM spacers for units set with silicone glazing sealant.
- E. Joint Cleaner, Primer and Sealer: As recommended by the glazing manufacturer.
- F. Compressible Filler Rod: Closed-celled or a waterproof-jacketed rod stock of synthetic rubber or plastic foam, compatible with sealants used, flexible and resilient, with 34.5 to 68.9 kPa compression strength for 25 percent deflection.
- G. Preformed Butyl-Polyisobutylene Glazing Tape: Provide manufacturer's standard solvent-free butyl-polyisobutylene formulation with a solids content of 100 percent; complying with AAMA A 804.1; in extruded tape form; non-staining and non-migrating in contact with nonporous surfaces; packaged on rolls with a release paper on one side; with or without continuous spacer rod as recommended by manufacturers of tape and glass for application indicated.
- H. Sealants: Conform to Section 07900 - SEALANTS.

3. PART 3 - EXECUTION

3.01 PREPARATION

- A. Clean glazing channels, stops and other framing members to receive glazing materials of obstructions and deleterious substances which might impair the work. Remove coatings which are not firmly bonded to substrates. Remove lacquer from metal surfaces where elastomeric sealants are indicated for use. Comply with manufacturer's instructions for final wiping of surfaces immediately before application of primer and glazing media.

3.02 INSTALLATION

A. General:

1. Unless otherwise shown or specified, comply with recommendations and requirements of the FGMA Glazing Sealing Systems Manual and Glazing Manual. For the installation of all glass comply with glass manufacturer's and glazing materials manufacturer's written instructions and recommendations.
2. Provide watertight and airtight installation of each piece of glass, so as to withstand temperature changes and wind loading normal at the site.
3. Operating sash and doors shall withstand impact loading without failure of any kind including loss or breakage of glass, failure of sealants or gaskets to remain watertight and airtight, and deterioration of glazing materials.
4. All butt-joint glazing according to the glass manufacturer's recommendations.

B. Inspection:

1. Inspect each piece of glass immediately before installation. Do not install any pieces which are improperly sized or have damaged edges, scratches or abrasion or any other evidence of damage.
2. Use suction cups to shift glass units within openings; do not drift glass with pry bars. Remove labels from glass immediately after installation.

C. Setting Blocks:

1. Locate setting blocks at sill rabbet one-quarter in from each end of the glass, unless otherwise recommended by the glass manufacturer.
2. Use blocks of proper size to support the glass in accordance with manufacturer's recommendations. Set blocks in thin course of sealant which is acceptable.

D. Spacers:

1. Provide spacers for all glass sizes larger than a combined total of 1.27 m or more for any two adjacent sides to separate glass from stops, except where continuous glazing gaskets are provided.
 2. Locate spacers no farther than 600 mm apart and no closer than 300 mm to a corner. Place spacers opposite one another. Make bite of spacer on glass a nominal 6 mm or greater.
- E. Set units of glass in each series with uniformity of pattern, draw, bow and similar characteristics.
- F. Provide compressible filler rods or equivalent back-up material, as recommended by sealant and glass manufacturers, to prevent sealant from extruding into glass channel weep systems and from adhering to joints back surface as well as to control depth of sealant for optimum performance, unless otherwise indicated.
- G. Sealants:
1. Force sealants into glazing channels to eliminate voids and to ensure complete bond of sealant to glass and channel surfaces.
 2. Tool exposed surfaces of sealants to provide a substantial "wash" away from glass. Install pressurized tapes and gaskets to protrude slightly out of channel, so as to eliminate dirt and moisture pockets.
 3. For further requirements refer Section 07900 - SEALANTS.
- H. Glazing Gaskets:
1. Miter-cut and seal joints of glazing gaskets in accordance with manufacturer's written instructions.
- I. Lock-Strip Gaskets:
1. Comply with gasket manufacturer's written instructions and recommendations. Miter-cut corners of loose zipper strips slightly longer to provide permanent compression at joints.
 2. Use special tool to install and remove filler strips; lubricate in accordance with manufacturer's instructions.
 3. Comply with glass manufacturer's written instructions for the use of setting blocks, liquid or tape sealants, and weep holes in the glazing recess of lock strip gaskets.

3.03 PROTECTION AND CLEANING

- A. Protect glass from breakage immediately upon installation by use of crossed streamers or ribbons attached to framing and held away from

glass. Do not apply markings to surfaces of glass. Remove nonpermanent labels and clean surfaces.

- B. Protect glass from contact with contaminating substances resulting from construction operations. Cover glass as required to protect it from additives that might abrade the glass surface. If, despite such protection, contaminating substances do come into contact with glass, remove immediately by method recommended by glass manufacturer.
- C. Remove and replace glass which is broken, chipped, cracked, abraded or damaged in other ways during construction period, including natural causes, accidents and vandalism.
- D. Maintenance: Maintain glass in a reasonably clean condition during construction.
- E. Cleaning: Wash glass on both faces not more than 4 days prior to acceptance. Comply with instructions and recommendations of the glass manufacturer and glazing materials manufacturer for cleaning in each case.

END OF SECTION

SECTION 09200

LATH AND PLASTER

1. PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Plaster accessories including metal lath and plastering beads as well as control joints.
- B. Cement plaster.
- C. Gypsum Plaster.
- D. Decorative fiber Reinforced Gypsum Units.
- E. Sand-cement screed.

1.02 REFERENCES

A. ASTM - American Society for Testing and Materials

ASTM A 109	Specification for Steel, Carbon, Cold-Rolled Strip
ASTM A 570	Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality
ASTM C 28	Specification for Gypsum Plasters
ASTM C 29	Test Method for Unit Weight and Molds in Aggregate
ASTM C 35	Specification for Inorganic Aggregates for Use in Gypsum Plaster
ASTM C 61	Specification for Gypsum Keene's Cement
ASTM C 150	Specification for Portland Cement
ASTM C 206	Specification for Finishing Hydrated Lime
ASTM C 472	Test Method for Physical testing of Gypsum Plasters and Gypsum concrete
ASTM C 841	Specification for Installation of Interior Lathing and Furring
ASTM C 842	Specification for Application of Interior Gypsum Plaster
ASTM C 847	Specification for Metal Lath
ASTM C 926	Specification for Application of Portland Cement-Based Plaster

B. ANSI - American National Standards Institute Inc.

ANSI A42.1 Gypsum Plastering

ANSI A42.3 Lathing and Furring for Portland Cement and Portland
Cement-line, Exterior (Stucco) and Interior

ANSI A42.4 Specification for Interior Lathing and Furring

C. ML/SFA - Metal Lathing/Steel Framing Association

ML/SFA Specification for metal lathing and furring

1.03 SUBMITTALS

- A. Manufacturer's Certificates: Submit manufacturer's certificates showing compliance with the specified material requirements and installation and workmanship instructions.
- B. Samples: Submit 300 mm long samples of the proposed accessories.

1.04 TRANSPORTATION, HANDLING AND STORAGE

- A. Except for sand and water, deliver materials to the site in sealed containers or bags fully identified with manufacturer's name, brand, type and grade. Store materials in a dry, well-ventilated space, under cover, off the ground, and away from surface subject to dampness or condensation.
- B. Deliver accessories in their original containers bearing the name of the manufacturer and production identification.

1.05 QUALITY ASSURANCE

- A. Allowable Tolerance for Finished Work: For flat surfaces, do not exceed 3 mm in 3 meters for bow or warp of surface and for plumbness or level.
- B. Mock-up Installation: Prior to installation of plaster work, provide sample mock-up panels using materials specified for final work. Build sample panels at site, of full thickness and approximately 1.2 x 1.2 m.

Demonstrate the proposed range of color, texture and workmanship to be expected in the completed work, and submit to the Engineer for review. Retain sample panels construction as a standard for judging completed plaster work. Do not alter, move or destroy sample panel until plastering work is completed. Provide a sample panel for interior and exterior portland cement plaster and plaster on metal lath.

1.06 JOB CONDITIONS

A. Protection:

1. General: Protect contiguous work from moisture deterioration and soiling, which may result from plastering operations. Provide temporary covering and whatever other provisions may be necessary to minimize harmful spattering of plaster on other work.
2. Finished door and window frames and other surfaces which do not receive a plaster finish shall be well protected during plaster application.

B. Environmental Conditions:

1. General: Protect plaster against uneven and excessive evaporation and from strong flows of dry air, both natural or artificial. Apply and cure plaster as required by climatic conditions to prevent rapid dry-out. Provide suitable coverings, moist curing, barriers to deflect sunlight and wind, or combination of these as required.
2. Ventilation: Provide adequate ventilation to properly dry interior plaster during and subsequent to its application.

2. PART 2 - PRODUCTS

2.01 PLASTER ACCESSORIES

- A. Galvanized steel furring, lathing and other plaster accessories shall conform to the material provisions of ASTM C 841 and ANSI A42.3. Plaster accessories shall include but not limited to the following:
1. Metal Corner Beads: Fabricated from galvanized sheet, 5 mm radius bead with 38 mm wide expanded type flanges.
 2. Strip Reinforcement: Smooth edge strips of expanded metal lath fabricated from galvanized steel sheet, with uncoated steel painted after fabrication.
 3. Casing Beads: Square-edged style, with short or expanded flanges to suit kinds of plaster bases galvanized steel.
 4. Curved Casing Beads: Square-edged style, fabricated from aluminum coated with clear plastic, preformed into curve of radius indicated on the Drawings.
 5. Control Joints: Prefabricated, galvanized steel one-or two-piece type as required. Provide removable protective tape on plaster face of control joints.

6. Metal Corner Reinforcement: Expanded large mesh diamond lath fabricated from welded wire mesh from 1.2 mm diameter galvanized wire, specially formed to reinforce corners of portland cement plaster where exposed while allowing full plaster encasement.
 7. Expanded Metal Lath: Galvanized steel diamond mesh complying with ASTM C 847 and shall have a minimum weight of 1.85 kg/m².
- B. Coordinate the depth of accessories with the thickness and number of plaster coats required in accordance with the manufacturer's recommendations and as directed by the Engineer.

2.02 PORTLAND CEMENT PLASTER

- A. Portland cement plaster shall have a minimum thickness of 20 mm in a double coat provided using but not limited to the following materials:
1. Base Coat Cement: Portland cement, conforming to ASTM C 150, Type I.
 2. Finish Coat Cement: Portland cement, conforming to ASTM C 150, Type I.
 3. Factory-Prepared Finish Coat: Manufacturer's standard product requiring only the addition of water; white in color unless otherwise indicated.
 4. Lime: Special hydrated lime for finishing purposes, conforming to ASTM C 206, Type S.
 5. Sand Aggregate for Base Coat: Conform to the requirements of ASTM C 897.
 6. Aggregate for Finish coat: Conform to ASTM C 897, manufactured or natural sand, white in color or as required to match the Engineer sample.
 7. Water for Mixing and Finishing Plaster: Potable, free of substances, capable of affecting plaster set or of damaging plaster, lath or accessories.
 8. Bonding Agents: Conform to ASTM C 932.
- B. Portland cement plaster mixes and compositions:
1. General: Comply with ASTM C 926 for portland cement plaster base and finish coat mixes as applicable to plaster bases, materials and other requirements indicated. Submit samples of materials used for the approval of the Engineer as well as mix design.

2. Base Coat: Proportion materials for respective base coats in parts by volume for cementitious materials and in parts by volume for sum of cementitious materials for aggregates to comply with following requirements for each method of application and plaster base as required. Adjust mix proportions indicated herein within the limits specified to attain workability as follows:
 - a. Two-coat Work over Concrete Unit Masonry: Base coats shall be one part portland cement: $3/4$ to $1\ 1/2$ parts lime : 3 to 4 parts sand.
3. Finish Coat: Proportion materials for finish coats in parts by volume for cementitious materials for aggregates with one part portland cement: $3/4$ to $1\ 1/2$ parts lime, 3 parts sand or one part portland cement, one part masonry cement, 3 parts sand, or as required.

2.03 GYPSUM PLASTER (FOR INTERNAL PLASTERING)

A. Gypsum Plaster Materials:

1. Base Coat Plaster: Conform to ASTM C 28, ready-mixed gypsum, high strength gypsum neat plaster with minimum average dry compressive strength of 19.3 MPa according to ASTM C 472 for a mix of 45 kg plaster and 0.19 m^3 of sand.
2. Finish Coat Plaster: Ready-mixed gypsum finished plaster, manufacturer's standard mill-mixed gauged interior finish or high-strength gypsum gauging plaster, conforming to ASTM C 28, with a minimum average dry compressive strength of 34.5 MPa according to ASTM C 472 for neat mix.
3. Lime: Conform to ASTM C 206, hydrated lime, Type S, for finishing purposes, unless otherwise indicated.
4. Aggregates for Base Coat: Conform to ASTM C 35, sand aggregate, unless otherwise indicated.
5. Bonding Agent: Conform to ASTM C 631.

B. Gypsum plaster mixes and compositions:

1. Plaster Base Coat Compositions: Comply with ASTM C 842 and manufacturer's directions for gypsum plaster base coat proportions which corresponds to application and plaster bases as indicated below:
 - a. Three-coat Work Over Metal Lath: Scratch and brown coats of high strength gypsum gauging plaster with job-mixed sand.
 - b. Two-Coat Work Over Unit Masonry and Concrete: Base coats of gypsum neat plaster with job-mix sand.

2. Finish Coat: Proportion materials for finish coat to comply with ASTM C 842 for type of finish coat and texture required.

2.04 DECORATIVE FIBER REINFORCED GYPSUM UNITS

- A. Fiber reinforced gypsum units: Pre-fabricated using un-layered spray lay-up procedures and combined with high strength gypsum plaster formulated specially for combination with glass fibers with no special additives. Fabricate units to the shapes, sizes and of the required thickness in accordance with detailed shop Drawings approved by the Engineer.
- B. Embeds and inserts: Non-combustible and metal components shall be zinc coated or galvanized.
- C. Miscellaneous Materials:
 1. Fasteners: Self-drilling, self tapping type drywall screws, length as required for each assembly.
 2. Wire Hangers: Minimum 12 gage galvanized steel wire.
 3. Joint Treatment: Conform to ASTM C 475; type as recommended by the manufacturer. Joint Tape shall be perforated type. Joint compound shall be ready mix vinyl-type for interior use. Provide bedding and topping type compounds.
 4. Adhesives: Construction type, as recommended by the Manufacturer.
- D. Fabrication:
 1. Construct molds for reinforced gypsum units of materials to result smooth, finished products conforming to sizes and shapes indicated on Drawings.
 2. Meter glass fiber and plaster slurry rates at spray head to achieve the desired mix proportioned fiber glass content.
 3. Machine spray conforming to the Manufacturer's standards for multi-directional, chopped fibers.
 4. Imbed wire hanger inserts in matrix to develop full strength.
 5. Remove units from molds and repair surface imperfections. Cure units in accordance with the Manufacturer's standards. Units final surface shall be primer ready.

2.05 SAND CEMENT SCREED

- A. Sand cement screed shall be composed of a mixture of Portland Cement type I, natural sand, crushed stone or a combination of them, as well as water and other additives as indicated on Drawings and as required by the Engineer.
- B. Submit the design mix for the Engineer approval. Screed shall have thickness indicated on Drawings.
- C. Test screed for a minimum compressive strength of 22 MPa after 28 days.
- D. Where indicated on drawings, provide epoxy coat hardner as per section 09900 – Painting, epoxy coat material shall be applied accordance with epoxy coat manufacturer instructions and recommendations. Epoxy coat shall be subject to approval of the Engineer.
- E. Where indicated on drawings, provide epoxy screed anti corrosion top layer 25 mm thick, epoxy screed material shall be compatible with substrate and shall be applied accordance with epoxy screed material manufacturer instructions and recommendations. Epoxy screed material shall be subject to approval of the Engineer.

3. PART 3 - EXECUTION

3.01 INSTALLATION OF LATHING AND FURRING - GENERAL

- A. Install interior lathing and furring materials indicated for plaster to comply with ASTM C 841.
- B. Install lathing and furring materials indicated for Portland cement plaster to comply with ANSI A42.3.
- C. Install supplementary framing, blocking, and bracing at terminations of work for support of fixtures, equipment services, heavy trim, grab bars, toilet accessories and similar work in accordance with details indicated on Drawings or approved shop drawings.
- D. Isolation: Where lathing and metal support system abuts building structure horizontally, and where partition/wall work abuts overhead structure, isolate the work from structural movement sufficiently to prevent transfer of loading into the work from the building structure. Install slip or cushion type joints to absorb deflections but maintain lateral support.
- E. Frame both sides of control and expansion joints independently, and do not bridge joints with furring and lathing or accessories.

3.02 INSTALLATION OF CEILING SUSPENSION SYSTEMS

- A. Coordinate installation of ceiling suspension system with installation of

overhead structural systems, ducting and catwalks to ensure that inserts and other structural anchorage provisions have been installed to receive ceiling hangers in a manner that will develop their full strength and at spacings required to support ceiling.

- B. Furnish concrete inserts, and other devices indicated, to other trades for installations well in advance of time needed for coordination with other work.
- C. Attach hangers to structure above ceiling to comply with ML/SFA - Specifications for Metal Lathing and Furring as well as with referenced standards.
- D. Install ceiling suspension system components of sizes and spacings indicated but not in smaller sizes or greater spacings than that required by the referenced lathing and furring installation standards.

3.03 METAL LATHING

- A. Install expanded metal lath for the applications where plaster base coats are required. Provide appropriate type, configuration and weight of metal lath selected from materials required which comply with referenced lathing installation standards.

3.04 INSTALLATION OF PLASTERING ACCESSORIES

- A. General: Comply with referenced lathing and furring installation standards for provision and location of plaster accessories of type indicated. Miter or cope accessories at corners; install with tight joints and in alignment. Attach accessories securely to plaster bases to hold accessories in place and alignment during plastering.
- B. Accessories:
 - 1. Corner Beads: Install at external corners.
 - 2. Casing Beads: Install at terminations of plaster work, except where plaster passes behind and is concealed by other work and where metal screed, bases or metal frames act as casing beads.
 - 3. Control Joints: Install at locations indicated, or if not indicated, at spacings and locations required by referenced standard and recommended by plaster manufacturer and approved by the Engineer.
 - 4. Corner Reinforcement: Install at external corners.

3.05 PLASTER APPLICATION

- A. Prepare monolithic surfaces for bonded base coats and use bonding compound or agent to comply with requirements of referenced plaster

application standards for conditioning of monolithic surfaces.

- B. Tolerances: Do not deviate more than 3 mm in 3000 mm from a true plane in finished plaster surfaces, as measured by a 3000 mm straightedge placed at any location on surface.
- C. Grout hollow metal frames and similar work occurring in plastered areas, with base coat plaster material, and prior to lathing where necessary. Except where full grouting is indicated or required for fire-resistance rating, grout 150 mm lengths at each anchorage.
- D. Sequence plaster application with the installation and protection of other work, so that neither will be damaged by the installation of the other.
- E. Plaster finish with metal frames and other built-in metal items or accessories which act as a plaster ground, unless otherwise indicated. Where plaster is not terminated at metal by casing beads, cut base coat-free from metal before plaster sets and groove finish coat the juncture with metal.
- F. Apply thickness and number of coats of plaster as indicated or as required by referenced standards, and as per manufacturer's recommendations.
 - 1. Cement Plaster: Base coat shall be 20 mm thick for concrete and CMU. Finish coat shall be 3 mm.
 - 2. Gypsum Plaster (for internal use): Base coat shall be 12 mm thick. Finish coat shall be 3 mm.
- G. Concealed Plaster: Where plaster application will be concealed by wood panelling, above suspended ceilings and similar locations, finish-coat may be omitted. Where plaster application will be concealed behind cabinets and similar furnishings and equipment, apply finish-coat. Where plaster application will be used as a base for adhesive application of tile and similar finishes, omit finish-coat and coordinate thickness with overall dimension as shown and comply with tolerances specified.

3.06 FIBER REINFORCED GYPSUM UNITS

- A. Inspect adjacent construction for conditions that would prevent the installation of the units.
- B. Expansion and Control Joints: As recommended by the Manufacturer.
- C. Install reinforced gypsum units true, plumb and level in accordance with the Manufacturer's installation instructions.
- D. Joint Finishing: Finish the joints carefully so as to avoid crowning in flat joints.
- E. Repair cracks and imperfections resulting after installation.

3.07 SAND-CEMENT SCREED

- A. Roughened the concrete slabs to receive screeding before hardening. Clean and wet the hardened base surfaces, preferably overnight prior to laying of screeds.
- B. Batch accurately aggregates and cement by weight at a ratio of cement-aggregate ranging from 1-3 to 1-4.5. Mix screeding material mechanically.
- C. Lay and finish the screed mix carefully to true levels and correct heights for the required thickness. Tolerance in level over a 2 m length shall not exceed plus or minus 3 mm.
- D. Provide adequate means of curing to prevent rapid drying of screed as directed by the Engineer.

3.08 CUTTING AND PATCHING

- A. Cut, patch, point-up and repair plaster as necessary to accommodate other work and to restore cracks, dents and imperfections. Repair or replace work to eliminate blisters, buckles, excessive crazing and check cracking, efflorescence and similar defects, and where bond to the substrate has failed.
- B. Sand smooth-trowelled finishes lightly to remove trowel marks and arises.

3.09 CLEANING AND PROTECTION

- A. Remove temporary protection and enclosure of other work. Promptly remove plaster from door frames, windows, and other surfaces which are not to be plastered. Repair floors, walls and other surfaces which have been stained or otherwise damaged during the plastering work. When plastering work is completed, remove unused materials, containers and equipment and clean remove unused materials, containers and equipment and clean floors of plaster debris.
- B. Provide final protection and maintain conditions which ensure plaster work being without damage or deterioration at the time of substantial completion.

END OF SECTION

SECTION 09310

CERAMIC TILES

1. PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Ceramic and tiles for walls and/or floors as indicated on Drawings.
- B. Miscellaneous materials including tile adhesive, grout, and sealants.

1.02 REFERENCES

A. ANSI - American National Standards Institute:

- A108.1 Installation of Glazed Wall Tiles
- A108.4 Ceramic Tiles Installed with Water-Resistant Organic Adhesives
- A118.1 Dry-Set Portland Cement Mortar
- A118.2 Conductive Dry-Set Portland Cement Mortar
- A118.3 Chemical-Resistant, Water Cleanable Tile-Setting and Grouting Epoxy
- A118.6 Ceramic Tile Grouts
- E136.1 Organic Adhesive for Installation of Ceramic Tiles
- A137.1 Standard Specification for Ceramic Tiles

B. ASTM - American Society for Testing and Materials:

- ASTM C 150 Specification for Portland Cement
- ASTM C 206 Specification for Finishing Hydrated Lime

C. TCA - Tile Council of America:

- TCA 137.1 Standard Specification for Ceramic Tile
- TCA Handbook for Ceramic Tile Installation

1.03 SUBMITTALS

- A. Complete set of samples of manufacturer's standard products for color selection.
- B. Certification from manufacturer of tile certifying the following:
 - Materials provided are suitable for intended use.

- Materials meet or exceed appropriate ANSI Standard.
- C. Tile manufacturer's complete installation instructions.
- D. Shop drawing layout showing the tile arrangements.

1.04 TRANSPORTATION, HANDLING AND STORAGE

- A. Deliver materials in containers with labels legible and intact and grade-seals unbroken. Store material so as to prevent damage or contamination.

1.05 QUALITY ASSURANCE

- A. Variation in plane of sub-floor, including concrete fills: Not more than 6 mm in 3 meters from required elevation where portland cement mortar setting bed is used and not more than 3 mm in 3 meters where dry-set portland cement, and latex-portland cement mortar setting beds and chemical resistant bond coats are used.
- B. Variation in plane of wall surfaces and surface of scratch coat: Not more than 6 mm in 2.40 meters from required plane where portland cement mortar setting bed is used and not more than 3 mm in 2.40 meters where dry-set or latex-portland cement mortar or organic adhesive setting materials are used.

2. PART 2 - PRODUCTS

2.01 CERAMIC TILES

A. General:

1. Ceramic tiles shall have a standard grade quality in accordance with the Grade Specifications of ANSI A137.1 or DIN 18166 or BS 1286.
2. Unless otherwise indicated, minimum requirements for ceramic wall and floor tiles shall be Grade-1, best quality glazed tiles, 6 mm thick for walls, 8 mm thick for internal floors and 10 mm thick for external floors.
3. Accessories: Provide the necessary manufacturer's standard trims and half pieces required for the complete installation.
4. Tile Manufacturer, Selection and Size: Ceramic tiles selection and size as shown on Drawings; color and pattern shall be as indicated on Drawings and as approved by the Engineer.

2.02 CERAMIC WALLS AND FLOORS:

A. Description: Provide glazed ceramic tiles for walls and glazed, non-slip, ceramic tiles for floors. The tiles shall be fully-fired vitrified clay from selected raw materials to the most rigorous quality control standards.

B. Technical Characteristics:

Water absorption : 0-2.0%

Density : 2.25-2.35 g/cm³

Bending strength : 300-350 kg/cm³

Glazed surface hardness : 6-9 (mohs)

2.03 MISCELLANEOUS MATERIALS

A. General:

1. Mortar and Grout Materials: Conform to ANSI A108.1 and A108.2. Mixture of Portland Cement: Sand for floors shall be roughly in proportions of 1 : 6, and for walls shall be Portland Cement : Sand : Hydrated Lime roughly in proportions ranging from 1:5:1/2 to 1: 7: 1.

2. Color Pigment: Manufacturer's standard mineral oxides, unaffected by lime cement or weathering. Use only when required for selected grout color. Color shall be as selected and approved by the Engineer.

B. Setting Mortar: Portland cement and sand mixed with liquid latex mortar additive to form high strength thin set mortars with chemical and shock resistance properties. Setting mortar composition and mix shall be as recommended by the manufacturer.

C. Organic adhesive: As recommended by the manufacturer for areas requiring prolonged water resistance, shall be type 1, ANSI A 136.1.

D. Grouting material: Latex-portland-cement, ready-mixed and as recommended by the ceramic tile manufacturer.

E. Sealants: Elastomeric type, in conformance with the requirements specified in Section 07900 - SEALANTS.

3. PART 3 - EXECUTION

3.01 GENERAL

- A. Installation of floor and wall tiles shall comply with the requirement of ANSI A108.1 through A108.6 and the TCA Handbook for Ceramic Tile Installation, unless otherwise indicated.
- B. Protection and Curing:
 - 1. Spaces in which tile is being set shall be closed to traffic and other work. Keep closed until tile is firmly set. Protect tile from damage.
 - 2. Damp cure for at least 3 days; add dampness as needed to achieve a hard cure.
- C. Jointing Pattern:
 - 1. Unless otherwise shown, lay tile in grid pattern. Align joints when adjoining tiles on floor, base, walls and trim are the same size. layout tile work and center tile fields both directions in each space or on each wall area. Adjust as necessary to avoid use of widths less than 1/2 tile at edge of walls. Provide uniform joints, not less than 5 mm and not more than 7 mm unless otherwise shown.

3.02 INSTALLATION OF WALL TILES

- A. Mortar Setting on Masonry Substrate
 - 1. Tiles shall be installed over masonry substrate with portland cement mortar in accordance with ANSI A108.1.
 - 2. Finished mortar bed shall have a minimum thickness of 19 mm.
- B. Setting Wall Tiles:
 - 1. Tiles shall not be soaked prior to installation.
 - 2. Tiles shall be pressed firmly into freshly notched mortar and shall be tapped and beaten to a true surface.
 - 3. Joint width shall be determined by spacers on tile or by strings or pegs if tile without spacers are used.
 - 4. Tiles shall be pressed and beaten into place to obtain at least 80 percent coverage by mortar on back of tile, except for areas with prolonged contact with water where coverage must be 100 percent.
 - 5. Tiles shall be adjusted before initial set of mortar takes place.
- C. Grouting Wall Tiles: Grouting shall be in strict accordance with the manufacturer's recommendations and shall be cured as required to produce a hard grout.

3.03 SEALING

- A. At all points where ceramic tiles abuts other materials, polyethylene sheeting shall be installed as a waterproof cleavage membrane.
- B. After tiles has set and cured, cleavage membrane shall be carefully cut out and joint shall be sealed.

3.04 CLEANING AND PROTECTION

- A. Upon completion of placement and grouting, all ceramic tiles surfaces shall be cleaned free of foreign matter.
 - 1. Glazed tiles surfaces shall be sponged and washed thoroughly joints and finally polished with clean, dry clothes.
 - 2. Unglazed tiles may be cleaned with cleaners and/or solvents recommended by tile manufacturer after completion of installation. Protect metal surfaces, cast iron and vitreous plumbing fixtures from effects of cleaning materials. Flush surfaces with clean water before and after cleaning.
- B. Finished installation shall be maintained clean and free of cracked, chipped, broken, unbonded or otherwise defective tile work.
- C. Apply a protective clear sealer coat(s) for unglazed tiles. Number of coats shall be as recommended by manufacturer. Protect installed tile work with Kraft paper or other heavy covering during the construction period to prevent damage.
- D. Before final inspection, remove protective coverings and rinse neutral cleaner from tile surfaces.

END OF SECTION

SECTION 09510

ACOUSTICAL CEILING

1. PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Grid suspension system for acoustical ceiling.
- B. Mineral fiber acoustical ceiling tiles as shown on the Drawings and as specified in this section.

1.02 REFERENCES

A. ASTM - American Society for Testing and Materials

ASTM A 446 Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Structural Quality

ASTM A 525 Steel Sheet Zinc-Coated (Galvanized) by Hot-Dip Process

ASTM A 614 Zinc-Coated (Galvanized) Carbon Steel Wire

ASTM C 423 Test for Sound Absorption of Acoustical Materials in Reverberation Rooms

ASTM C 523 Light Reflectance of Acoustical Material

ASTM E 90 Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions

ASTM E 84 Test for Surface Burning Characteristics of Building Materials

ASTM C 635 Specification for Metal Suspension Systems for Acoustical Tile and Lay-In Panel Ceilings

ASTM C 636 Recommended Practice for Installation of Metal Ceiling Suspension System for Acoustical Tile and Lay-In Panels

ASTM C 637 Tests for Strength Properties of Prefabricated Architectural Acoustical Materials

B. UL - Underwriters Laboratories, Inc.

UL Fire Resistance Directory

1.03 SUBMITTALS

- A. Samples of grid system components and ceiling tiles.

- B. Certification that the components meet the requirements and tests specified.

1.04 TRANSPORTATION, HANDLING AND STORAGE

- A. Deliver acoustical ceiling units to project site in original, unopened packages and store them in fully enclosed space where they will be protected against damage from humidity, direct sun light, surface contamination, and other causes. Handle acoustical ceiling units carefully to avoid chipping edges or damaging units in any way.

1.05 WARRANTY

- A. Submit written guarantee signed by the contractor and manufacturer for 2 years from the date of substantial handover. Guarantee shall cover repair and replacement of defective material and workmanship.

1.06 QUALITY ASSURANCE

- A. Engage an experience installer who has successfully completed acoustical ceilings similar in material, design and extent to that indicated for the Project.

1.07 PROJECT CONDITIONS

- A. Do not install acoustical materials unless temperature and humidity conditions closely approximate the interior conditions which will exist when the building is occupied. Maintain temperature and humidity conditions during and after installation. Plastering , concrete and terrazzo work (including grinding) shall be complete dry. Windows and doors shall be in place and glazed.

2. PART 2 - PRODUCTS

2.01 SUSPENSION SYSTEM

- A. General: Ceiling tile manufacturer's standard suspension system fabricated of cold-rolled hot-dipped galvanized sheet steel components providing minimum 170 g/m² zinc coating conforming BS 2989 or ASTM A 653. System shall be designed and fabricated to meet the requirements of ASTM C 635 or equivalent BS standards. Finish shall be electro-statically applied powder coated polyester paint, white color or as approved by the Engineer.
- B. Hanger Wires: Galvanized steel wires, pre-stretched, not less than 2 mm diameter.

- C. Hanger Wire Anchors: Drill-in type as approved by the Engineer.
- D. Accessories: Edge Moldings, hold-down clips and other necessary accessories shall be provided in accordance with the Engineer selection and approval.

2.02 ACOUSTICAL CEILING TILE

- A. Acoustical ceiling tiles shall be of mineral fiber of modular design and sizes and shall be of size 600 x 600 x 19 mm thick, unless otherwise indicated on the drawings. Tiles shall be fit the pattern as shown on the drawings. Mineral fiber tiles conforming to BS 476, Class O/ Class 1 or ASTM E 1264 or Federal Specifications FS-SS-S-118B, Type III, form 1 units; Class A; STC Range of 34-40 dB; NRC from 0.50 to 0.70; density of 240-260 kg/m³; RH of 90%; Flame Spread of 0-25 and Smoke Developed 0-50 in accordance with ASTM E 84 or equivalent standards.
 - Finish: Factory-applied washable white finish or as shown in drawings and approved by the Engineer, with light reflectance value of LR over 75 percent.
- B. Access Hatches: Provide manufacturer standard access hatches which are designed specially for the acoustical ceiling systems. Provide the access hatches with complete features including door locks, frames, pivots, metal trims and gaskets.

3. PART 3 - EXECUTION

3.01 INSTALLATION

- A. The installation of all acoustical ceiling work covered in this section shall be done by a qualified subcontractor for acoustical ceiling systems work recommended by the manufacturer, having at least 5 years experience in successfully completed projects.

3.02 SUSPENSION SYSTEM

- A. Installation of suspension system shall be in accordance with BS 8290 or ASTM C 636 and in accordance with manufacturer's directions.
- B. Rough Suspension:
 - 1. Space hanger wires at 1200 mm on centers, each direction. Supported from structural angle runners by looping and wire-tying.
 - 2. Hangers shall be installed at ends of each suspension member and at light fixtures, 150 mm from vertical surfaces.

3. Wires shall not be splayed more than 125 mm in a 1200 mm vertical drop.
 4. Wire shall be wrapped a minimum of three times horizontally, turning the ends upward.
- C. System shall be level within tolerance specified and parallel with walls.
- D. Wall moldings shall be installed at intersection of suspended ceiling and vertical surfaces.
1. Corners shall be mitered where wall moldings intersect or corner caps shall be installed in lieu thereof.
 2. Continuous ribbon of acoustical adhesive or caulking compound shall be applied on vertical web.
 3. Attachment to vertical surface shall be by means of mechanical fasteners.

3.03 CEILING TILES

- A. Installation of acoustical ceilings shall not begin until the building has been closed to weather with Relative Humidity not more than 70 percent.
- B. Ceiling tiles shall be in a levelled plane and in straight line courses.
- C. Provide cutting and patching for the passage of materials of other trades.

3.04 CLEANING

- A. Clean exposed surfaces of acoustical ceiling including trims, edges, moldings and suspension members. Comply with manufacturer's instructions for cleaning and touch-up of minor finish damage. Remove and replace work which cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.

END OF SECTION

SECTION 09545

METAL CEILING

1. PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Pan metal systems shown on the Drawings and as specified in this section.

1.02 REFERENCES

- A. ASTM - American Society for Testing and Materials

ASTM C 635 Metal Suspension Systems

ASTM C 636 Installation of Metal Ceiling Suspension Systems

1.03 SUBMITTALS

- A. Product Data: Submit Manufacturer's technical data for the metal ceiling components and the related suspension system showing compliance with the requirements specified herein.
- B. Shop Drawings: Submit shop drawings indicating grid layout, related dimensions, and junctions with other work or ceiling finishes, interrelationship of mechanical and electrical items related to system.
- C. Samples: Submit samples of the ceiling components for the Engineer's review and selection of color and texture.

1.04 TRANSPORTATION, HANDLING AND STORAGE

- A. Conform to the Manufacturer's requirements and recommendations for transportation, handling and storage.

1.05 QUALITY ASSURANCE

- A. Job Mock-Up: Prior to the installation of metal ceiling work, erect one sample, 1500 x 1500 mm as directed by the Engineer. Obtain the Engineer's approval of the mock-up before proceeding with installation. Retain mock-up during construction as a standard for judging completed metal ceiling work.

2. PART 2 - PRODUCTS

2.01 GENERAL METAL CEILING

A. Suspension System (for Metal Pan Ceiling Panels):

1. Manufacturer's standard spring-T concealed grid clip-in type suspension system manufactured from electro-galvanized mild steel comprising of channels to which secondary spring tees are attached, and shall be providing a firm grip for the ceiling panels.

B. Metal Ceiling Panels:

1. Metal Pan Ceiling Panels: Manufacturer's standard panels manufactured from electro-galvanized mild steel with an electro-statically factory applied finish comprising minimum 60 microns of powder coated polyester paint, satin finish, white color. 600 x 600 mm panels formed to snap on and be securely retained on carriers without separate fasteners. Ceiling panels shall have following characteristics:

- Humidity Resistance : 90%
- Light Reflectance : > 90%
- Fire Performance : Class 0/Class 1 (BS 476)

3. PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install metal ceiling system in accordance with manufacturer's written instructions to produce finished ceiling to the tolerances specified herein, free of warped, soiled, or damaged grid, panels and other components.
- B. Coordinate location of hangers with other work. Verify layout of hangers and locate to accommodate fittings and units of equipment placed after installation of ceiling system.
- C. Where ducts or other equipment prevent regular spacing of hangers, reinforce nearest adjacent hangers and related carrying channels required to span the distance.
- D. Install hangers/inserts in coordination with overhead work and provide additional hangers/inserts as required.
- E. Hang independently of walls, columns, ducts, pipes and conduits. Where carrying members are spliced, avoid visible displacement of longitudinal axis or face plane of adjacent members.
- F. Install ceilings in accordance with the final reflected ceiling layout and symmetrical in both directions from the center line of the area.

- G. Support fixture loads by supplementary hanger located within 152 mm of each corner when weight of fixture causes the dead load to exceed the deflection capability. Support the fixtures independently.
- H. Install angle moldings at intersection of ceiling and vertical surfaces, using maximum lengths, true and level. Miter all corners.

3.02 TOLERANCE

- A. Install ceiling system in a manner capable of supporting superimposed loads with maximum permissible deflection of $1/360$ of span and a maximum surface deviation of 3 mm in 3000 mm.

3.03 ADJUSTING, CLEANING AND PROTECTION

- A. Adjust sags or twists which develop in the ceiling system. Replace damaged or faulty parts.
- B. Clean exposed surfaces of metal ceilings, including trims, edge moldings and suspension members. Comply with manufacturer's instructions for cleaning and touch-up of minor finish damage. Remove and replace work which cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.
- C. Protect metal ceilings, maintaining such temperature and humidity limitations and dust control, that the work will be without damage and deterioration till the date of substantial completion of the Project.

END OF SECTION

SECTION 09600

STONE WORK

1. PART 1 - GENERAL

1.01 SECTION INCLUDES

Furnishing and installation of all interior and exterior stone work including cladding, capping, flooring, stairs and counters as indicated on the drawings and as specified in this section including the following:

- A. Marble for floors and walls including matching base.
- B. Granite for floors and walls including matching base.
- C. Stone for floors and walls including matching base.
- D. Anchors and attachments, setting materials, grouts, and accessories related to marble, granite and stone works.

1.02 SUBMITTALS

- A. Product Data: Submit manufacturer's technical data for the type of marble, granite and stone as well as accessories and other manufactured products required.
- B. Samples: Submit samples in the form of sets for each color, grade, finish, type and variety of materials required. Sample size shall be 600 x 600 mm. Include 2 or more samples in each set showing full range of variations in appearance and characteristics to be expected in the completed work also submit samples of fixing devices and joint sealants for the approval of the Engineer.

1.03 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Protect marble, granite, stone, mortar materials and accessories during storage and construction against moisture, soiling, staining and physical damage.
- B. Handle marble, granite, and stone tiles in a manner to prevent chipping, breakage, soiling or any other damage.
- C. Store marble, granite and stone tiles on wood skids or pallets covered with a waterproof non-staining membrane.

1.04 QUALITY ASSURANCE

- A. Single Source Responsibility: Obtain each color, grade, finish, type and variety of marble, granite and stone from a single quarry, approved by the Engineer.
- B. Execute the work under this Section through a specialized firm approved

by the Engineer and having at least 5 years experience in successful projects.

2. PART 2 - PRODUCTS

2.01 MARBLE

- A. Marble - General: Marble for flooring as well as stairs treads and risers shall be cut from sound stock with even texture, shade, marking, free from imperfections and as approved by the Engineer.
 - 1. Type, size, color, texture and finish of marble shall be as indicated on Drawings and as approved by the Engineer.
 - 2. Obtain marble from one quarry with consistent color range and texture throughout the work.
- B. Marble for Wall Cladding, Bases and Flooring: Unless otherwise indicated on Drawings, marble shall be 20 mm thick, length and width dimensions of individual slabs within plus or minus 1 mm, thickness within 2 mm from those specified.
- C. Marble for Stair Treads and Risers: Unless otherwise indicated on Drawings, marble shall be 30 mm for treads with non-slip nosing and 20 mm for risers.
- D. Marble for Counter Cladding and Tops: Thickness shall be as indicated on Drawings with exposed rounded and polished edges and matching splash back.

2.02 GRANITE

- A. Granite - General:
 - 1. Type, size, color, texture and finish of granite shall be as indicated on Drawings and as approved by the Engineer.
 - 2. Provide granite of the highest density available for the particular type selected.
 - 3. Obtain granite from one quarry with consistent color range and texture throughout the work.
- B. Provide granite to the shapes and sizes indicated on the Drawings with length and width dimensions of each individual slab within plus or minus 1 mm and thickness within 2 mm from those specified.
- C. Unless otherwise indicated, granite tiles thickness for wall cladding, bases and floor tiles shall 20 mm.

- D. Granite for stair treads and risers shall be of sizes as indicated on Drawings, thickness not less than 20 mm for treads with non-slip nosing and 20 mm for risers.
- E. Granite for Counter Cladding and Tops: Thickness shall be as indicated on Drawings with exposed rounded and polished edges and matching splash back.
- F. Granite shall be laid with matching grain and color.

2.03 Stone

- A. General: Stone for flooring, wall cladding as well as stairs treads and risers shall be cut from sound stock with homogenous color, texture, free from imperfections and as approved by the Engineer.
 - 1. Type, size, color, texture and finish of stone shall be as indicated on Drawings and as approved by the Engineer.
 - 2. Obtain stone from one quarry with consistent color range and texture throughout the work.
- B. Stone for Wall Cladding, Bases and Flooring: Unless otherwise indicated on Drawings, stone shall be 50 mm thick, length and width dimensions of individual slabs within plus or minus 2 mm, from those specified.
- C. Stone for Stair Treads and Risers: Unless otherwise indicated on Drawings, stone shall be 40 mm for treads with non-slip nosing and 30 mm for risers.
- D. Stone for Counter-Tops: Unless otherwise indicated on Drawings, shall be 50 mm thick with exposed edges rounded and polished and matching splash back.

2.04 MISCELLANEOUS MATERIALS

- A. Setting Materials:
 - 1. Portland Cement: ASTM C 150, Type I, except complying with staining requirements of ASTM C 91 for not more than 0.03 percent water soluble alkali.
 - 2. Hydrated Lime: ASTM C 207, Type S.
 - 3. Aggregate: ASTM C 144, non-staining, except graded with 100 percent passing the No. 16 sieve for 6 mm and narrower joints.
 - a. For white pointing mortar and grout, use natural white sand or ground white stone.

- b. For colored aggregate pointing mortar and grout, use fine aggregate produced from natural sands or ground stone including marble, granite or other sound stone as selected to produce mortar color indicated.
 4. Water: Potable, clear and free from deleterious materials which would impair the work.
- B. Grouts:
 1. Ready mixed, cement based, consisting of cement, carefully selected fillers and additives to provide workability. Grouts shall have good adhesion to dry marble and granite pieces and shall be so formulated to avoid drying, shrinkage and cracking.

Mixing shall be in accordance with the manufacturer's instructions. Color and shade of grouts shall be as directed by the Engineer.
- C. Control Joints:
 1. Form control joints to allow for movement in the floor at locations recommended by the manufacturer or as directed by the Engineer. Fill control joints with elastomeric material recommended by the manufacturer. No control joints material shall be allowed to project above the finished surface level.
- D. Anchors and Attachments:
 1. Provide anchors and attachments of type and size required to support the tiles from the following metals for conditions and anchors indicated below:
 - a. Stainless Steel: Type 304, for anchors, dowels and clamps in direct contact with stone.
 - b. Cast or Malleable Iron: For adjustable inserts embedded in concrete and not in direct contact with stone.
 - c. Hot-Dip Galvanized Steel: For anchor bolts, nuts and washers not in direct contact with stone; comply with ASTM A 307, Grade A, for material and ASTM C 153, Class C for galvanizing. For steel plates shapes and bars not in direct contact with stone; comply with ASTM A 36 for material and ASTM A 123 for galvanizing. Fixing devices shall be provided by a specialized firm as approved by the Engineer.
 2. Dove-tail Slots: Where indicated, furnish dove-tail slots with filler strips, of slot size required to receive anchors provided, fabricated from gage 22 galvanized sheet steel complying with ASTM A 446, Designation G-90.

E. Accessories:

1. Setting Buttons: Resilient plastic buttons, with no staining effect on the tiles, sized to suit joint thickness and bed depth of stone work involved without intruding into required depths of joint sealants or causing third-side adhesion between sealant and setting button.
2. Sealer for Floors: Colorless, slip and stain resistant sealer which will not affect color or physical properties of marble, granite and stone surface, as recommended by sealer and by stone manufacturer for application indicated.
3. Cleaner: Provide cleaners of proper formulation for kinds of marble, granite and stone, finishes and applications indicated, as recommended by the stone manufacturer and if sealer specified by sealer manufacturer. Do not use acid-type cleaning agents or other cleaning compounds containing caustic or harsh fillers except where expressly approved by the stone manufacturer for type of condition involved.

2.05 FABRICATION

- A. Fabricate as shown and as detailed on approved shop drawings. Provide holes and sinkages, cut or drilled for anchors, fasteners, supports and lifting devices, as shown and as necessary to secure stone work in place.
- B. Contiguous Work: Provide reveals, openings and similar spaces and features as required for contiguous work also coordinate with Drawings and approved shop drawings showing contiguous work.
- C. Cut accurately to shape and dimension shown on the shop drawings. Dress joints straight and at right angles to face, unless otherwise indicated. Cut to provide joint width as shown on the Drawings or as directed by the Engineer. Field cutting is not allowed.
- D. Pattern Arrangement: Fabricate marble, granite and stone to the patterns indicated on Drawings and in accordance with approved shop drawings.

3. PART 3 - EXECUTION

3.01 INSTALLATION - GENERAL

- A. Clean stone (marble, granite and stone) before setting by scrubbing with fiber brushes and thoroughly drenched with water.
- B. Stone work shall be done by experienced workmen of the trade employing skilled stone fitters at the site for necessary field cutting as stone is set.
- C. Where stone will come in contact with ferrous metal surfaces, apply an approved anti-corrosion paint on the metal surfaces prior to setting as well as using approved rust inhibitors as pre-primers after primary preparation.
- D. Set stone work in accordance with Drawings and approved shop drawings for the stone work and provide expansion joints where required.
- E. Do not use stone units with chips, cracks, voids, stains or any other defects which might be visible in the finished work.
- F. Expansion and Control Joints: Provide for expansion and control joints of width and at locations indicated, sealant material complying with the requirements of Section 07900 - SEALANTS.

3.02 INSTALLATION - WALL CLADDING

- A. Support each stone with both gravity and lateral anchors of type and number indicated complying with the requirements indicated for material and performance.
- B. Attach anchors securely to stones and to back-up surfaces. Attach framing for stone support system to structural frame of building at connection points indicated by welded or bolted field connections.
- C. Where required, fill anchor holes with mortar and where dowel holes occur at pressure-relieving joints, provide compressive material above and below dowels.
- D. Install concealed flashing at continuous shelf angles, lintels, ledges and similar obstructions to the downward flow of water so as to divert such water to the exterior.
- E. Keep cavities open where unfilled space is indicated between back of stone and back-up wall. Do not fill cavities with mortar or grout unless otherwise indicated or directed by the Engineer.
- F. Upon completion of work, apply joint sealants as per instructions and at locations shown on Drawings and as specified in Section 07900 - SEALANTS.

3.03 INSTALLATION - FLOORS

- A. Setting of Floors in Portland Cement Mortar Bed:

1. Saturate concrete subfloor with clean water several hours before placing setting bed. Remove surface water about one hour before placing setting bed.
2. Apply slush coat of cement grout over surface of concrete subfloor about 15 minutes prior to placing of setting bed. Limit area to avoid its drying out prior to placing of setting bed. Slush coat shall be properly mixed and shall not exceed the thickness of 1.5 mm.
3. Mix setting bed in proportions by volume of one part of cement to 3 parts of sand (measured in damp loose condition) to the quantity of water to produce a stiff mixture with a moist surface when setting bed is ready to receive flooring.
4. Spread and screed setting bed to uniform thickness indicated to produce sub-grade elevations required for accurate setting of tiles to finished floor elevations shown. Mix and place only the amount which can be covered with prior to initial set. Cut back, bevel edge, remove and discard setting bed which has reached initial set prior to the placing of tiles.
5. Butter backs of flooring units with skim coat of neat cement and water just prior to placing it on bed.
6. Tamp flooring units until firmly bedded to proper finished floor elevations indicated also set and level each unit in single operation. Do not return to areas already set and disturb for leveling purposes prior to initial set of cement bed.

B. GROUTING - FLOORS

1. Mix grout in proportion, by volume of one part portland cement to 2 parts fine aggregate (measured in damp loose conditions). Except for thin joints with fine sand, reduce fine aggregate proportion to one part. Add liquid admixtures in proportion and concentration as per manufacturer's recommendations. Select grout materials to match the approved samples.
2. Grout joints in flooring units, except at expansion and control joints indicated to be filled with sealant. Fill all gaps to produce a finished joint which is uniform in color, smooth and without voids, pinholes or low spots.
3. Remove grout spillage from face of stone as the work progresses.
4. Cure grout by maintaining in a moist condition for not less than 7 days.

3.04 REPAIR AND CLEANING

- A. Units which are broken, chipped, stained or otherwise damaged shall be

removed and replaced.

- B. Clean stone work after completion using clean water and stiff bristle brushes. Do not use wire brushes, acid type cleaning agents or compounds with caustic or harsh fillers.
- C. Apply sealer to cleaned interior flooring in compliance with sealer manufacturer's instructions.

3.05 PROTECTION

- A. Provide proper procedures required to protect the stone work from collapse, deterioration, discoloration or damage during construction and until the acceptance of work.

END OF SECTION

SECTION 09650

RESILIENT FLOORING

1. PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Resilient flooring.
- B. Resilient base.

1.02 REFERENCES

- A. ASTM - American Society for Testing and Materials

ASTM D 257- Test Methods for DC Resistance or Conductance of Insulating Materials

ASTM E 84 - Test for Surface Burning Characteristics of Building Materials

1.03 SUBMITTALS

- A. Submit shop drawings and product technical data.
- B. Provide seaming plan and location of joints.
- C. Provide product data on specified products, describing physical and performance characteristics, sizes, patterns and colors available.
- D. Submit 2 samples, in actual size, illustrating color and pattern for each floor material specified.
- E. Submit manufacturer's installation instructions.
- F. Submit cleaning and maintenance data include maintenance procedures, recommended maintenance materials, and suggested schedule for cleaning, stripping, and re-waxing.

1.04 TRANSPORTATION, HANDLING AND STORAGE

- A. Deliver materials to site in original sealed packages or containers, clearly marked with the Manufacturer's name or brand, type and color, production run number and date of manufacture.
- B. Store materials in weathertight and dry storage facility. Protect from damage from handling, weather, and construction operations before, during and after installation.

1.05 GUARANTEE

- A. Submit a written guarantee signed by Contractor and Manufacturer for a period of 2 years from the date of substantial handover. Guarantee shall

cover repair and replacement of defective material and workmanship.

1.06 QUALITY ASSURANCE

- A. Install resilient flooring and accessories in strict compliance with manufacturer recommendations and instructions.
- B. Install resilient flooring and accessories after other finishing operation, including painting, have been completed.
- C. Do not install resilient flooring on concrete slabs until slabs have been cured and are sufficiently dry to achieve bond with adhesive as determined by Manufacturer's recommended bond and moisture test.

2. PART 2 - PRODUCTS

2.01 RESILIENT FLOORING MATERIALS

- A. Vinyl flooring rolls and tiles: Vinyl flooring shall be in compliance with the following requirements:
 - 1. Construction: Non asbestos, Homogenous vinyl flooring with foam interlayer and polyurethane reinforcement in compliance with DIN 16952 or 16952/T3
 - 2. Color: As indicated on Drawings
 - 3. Size: Tiles 300x300mm, Sheets (Rolls) 2x25 meters approx, unless otherwise indicated on Drawings,
 - 4. Total Thickness: Unless otherwise indicated on Drawings, total thickness shall be 3 mm.
 - 5. Resistant to static electricity.
 - 6. Abrasion/Thickness Loss: 0.15 mm maximum; in Compliance with DIN 51963
 - 7. Wear by Castor: Suitable; in compliance with the DIN 54324.
 - 8. Flame Spread: Class B1 in accordance with DIN 4102 as well as BS 476: Part 7.
 - 9. Chemical Resistance: Resistant; in compliance with DIN 51958.
 - 10. Light Fastness: > Level 6; in compliance with the DIN 53388.
 - 11. Electrical Resistance: 10^{11} Ohm in compliance with ASTM D 257.

12. Flexible no cracks under folding in compliance with BS6826.
- B. Pad and vinyl coating resilient flooring: Compliance with the following requirements:
1. Substrate Filler: As recommended by adhesive and vinyl flooring manufacturers; compatible with substrate.
 2. Adhesive: Type recommended by vinyl flooring manufacturer to suit application to substrate.
 3. Flooring Covering Pad Materials: Synthetic material, 20mm thick. Type shall be as recommended by vinyl flooring manufacturer and as approved by the Engineer to suit final vinyl coating material and intent of use.
 4. Flooring Vinyl Coating Materials: Synthetic vinyl coat material, Non asbestos, Homogenous, total thickness 2mm. Type and color shall be as recommended by vinyl flooring manufacturer and as approved by the Engineer to suit intent of use.
 5. Size: Manufacturer standard sheets (Rolls) sizes for pad materials and full space area for vinyl coatings.
 6. Total Thickness: Surface vinyl coat 2 mm thick and pad layer 20 mm thick.
 7. Resistant to static electricity.
 8. Abrasion/Thickness Loss: 0.15 mm maximum; in Compliance with DIN 51963
 9. Wear by Castor: Suitable; in compliance with the DIN 54324.
 10. Flame Spread: Class B1 in accordance with DIN 4102 as well as BS 476: Part 7.
 11. Chemical Resistance: Resistant; in compliance with DIN 51958.
 12. Light Fastness: > Level 6; in compliance with the DIN 53388.
 13. Electrical Resistance: 10^{11} Ohm in compliance with ASTM D 257.
 14. Flexible no cracks under folding in compliance with BS6826.
- C. Vinyl Base: Manufacturer's standard weldable vinyl base with color matching the floor covering. Provide the Manufacturer's matching end stops and preformed or molded corner units.
- D. Adhesive: Waterproof adhesive; type as recommended by the

manufacturer to suit material and substrate conditions.

- E. Concrete Slab Primer: Non-staining primer; type as recommended by the manufacturer.
- F. Leveling Compound: Latex-type compound; as recommended by the manufacturer.
- G. Divider Strips: Where indicated between different floor finishes, divider strip shall be 32 x 3 mm thick bronze or aluminum, angle or T-Type with appropriate anchoring devices to substrate.

3. PART 3 - EXECUTION

3.01 SUB-FLOOR PREPARATION

- A. Broom clean or vacuum surfaces to be covered and inspect subfloor. Start of flooring installation indicate acceptance of subfloor conditions and full responsibility for completed work.
- B. Perform bond and moisture tests on concrete slab to determine that concrete surfaces are sufficiently, cured dried and ready to receive flooring.
- C. Apply concrete slab primer, if recommended by flooring Manufacturer, prior to application of adhesive. Apply in compliance with Manufacturer's directions.
- D. Use leveling compound as recommended by flooring Manufacturer for filling small cracks and depressions in subfloors.

3.02 INSTALLATION

- A. Install flooring in strict compliance with the Manufacturer's recommendations.
- B. Tightly cement flooring to sub-base without open cracks, voids, raising and puckering at joints, telegraphing of adhesive spreader marks or other surface imperfections. Hand roll flooring at perimeter of each covered area to assure adhesion.
- C. Extend flooring into toe spaces, door reveals and into closets and similar openings.
- D. Maintain reference markers, holes or openings that are in place or plainly marked for future cutting by repeating on finish flooring as marked on subfloor. Use chalk or other non-permanent marking device.

- E. Accessories: Place resilient edge strips tightly butted to flooring and secure with adhesive. Install resilient edge strip at edge of resilient flooring, which would otherwise be exposed.

3.03 CLEANING

- A. Remove any excess adhesive or other surface blemishes, using neutral type cleaners as recommended by flooring Manufacturer. Protect installed flooring, which would otherwise be exposed.
- B. Immediately before acceptance of building, thoroughly clean resilient floors and accessories with neutral cleaners as recommended by Manufacturer and machine buff to a high sheen.

END OF SECTION

SECTION 09671

RESINOUS FLOORING

1. PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. General-use epoxy-resin flooring hardener.

1.02 SUBMITTALS

- A. Product Data: For each type of product specified. Include manufacturer's technical data, installation instructions, and recommendations for each resinous flooring component required.
- B. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors, textures, and patterns available for each resinous flooring system indicated.
- C. Samples for Verification: Of each resinous flooring system required, 150 mm square, applied by Installer for this Project to a rigid backing, in color, texture, and finish indicated. Where finishes involve normal color and texture variations, include Sample sets showing the full range of variations expected.
- D. Material Test Reports: From a qualified independent testing agency indicating and interpreting test results of the resinous flooring's reaction to chemicals and other reagents and substantiating compliance with requirements.

1.03 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced installer (applicator) who has specialized in installing resinous flooring similar in material, design, and extent to that indicated for this Project and who is acceptable to resinous flooring manufacturer.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials in original packages and containers, with seals unbroken, bearing manufacturer's labels indicating brand name and directions for storage and mixing with other components.
- B. Store materials to comply with manufacturer's written instructions to prevent deterioration from moisture, heat, cold, direct sunlight, or other detrimental effects.

1.05 PROJECT CONDITIONS

- A. Environmental Limitations: Comply with resinous flooring manufacturer's written instructions for substrate temperature, ambient temperature, moisture, ventilation, and other conditions affecting resinous flooring installation.

- B. Lighting: Provide permanent lighting or, if permanent lighting is not in place, simulate permanent lighting conditions during resinous flooring installation.
- C. Close spaces to traffic during resinous flooring application and for not less than 24 hours after application, unless manufacturer recommends a longer period.

2. PART 2 - PRODUCTS

2.01 MATERIALS

- A. Resinous Flooring: Resinous floor surfacing system consisting of primer; body coat(s) including resin, hardener, aggregates, and colorants, if any; and sealing or finish coat(s). Comply with requirements indicated in the Resinous Flooring Schedule.
- B. Patching and Fill Material: Resinous product of or approved by resinous flooring manufacturer and recommended by manufacturer for application indicated.
- C. Unless otherwise indicated on Drawings, epoxy-resin flooring hardener screed total thickness shall be 25 mm.

3. PART 3 - EXECUTION

3.01 PREPARATION

- A. General: Prepare and clean substrate according to resinous flooring manufacturer's written instructions for substrate indicated. Provide clean, dry, and neutral substrate for resinous flooring application.
- B. Concrete Substrates: Provide sound concrete surfaces free of laitance, glaze, efflorescence, curing compounds, form-release agents, dust, dirt, grease, oil, and other contaminants incompatible with resinous flooring.
 - 1. Comply with ASTM C811 requirements, unless manufacturer's written instructions are more stringent.
 - 2. Repair damaged and deteriorated concrete according to resinous flooring manufacturer's written recommendations.
- C. Resinous Materials: Mix components and prepare materials according to resinous flooring manufacturer's written instructions.
- D. Use patching and fill material to fill holes and depressions in substrates according to manufacturer's written instructions.

- E. Treat control joints and other nonmoving substrate cracks to prevent cracks from reflecting through resinous flooring according to manufacturer's written recommendations.

3.02 APPLICATION

- A. General: Apply components of resinous flooring system according to manufacturer's written instructions to produce a uniform, monolithic wearing surface of thickness indicated.
 - 1. Coordinate application of components to provide optimum adhesion of resinous flooring system to substrate and optimum intercoat adhesion.
 - 2. Cure resinous flooring components according to manufacturer's written instructions. Prevent contamination during application and curing processes.
 - 3. At substrate expansion and isolation joints, provide joint in resinous flooring to comply with resinous flooring manufacturer's written recommendations.
- B. Apply primer over prepared substrate at manufacturer's recommended spreading rate.
- C. Apply self-leveling slurry body coat(s) in thickness indicated.
- D. Apply troweled or screeded body coat(s) in thickness indicated. Hand or power trowel and grout to fill voids. When cured, sand to remove trowel marks and roughness.
- E. Apply sealing or finish coat(s), including grout coat, if any, of type recommended by resinous flooring manufacturer to produce finish indicated. Apply in number of coats and at spreading rates recommended in writing by manufacturer.

3.03 FIELD QUALITY CONTROL

- A. Core Sampling: At the direction of Owner and at locations designated by Owner, take 1 core sample per 93 sq.m of resinous flooring, or portion of, to verify thickness. For each sample that fails to comply with requirements, take 2 additional samples. Repair damage caused by coring and correct deficiencies at no additional cost to Owner.

3.04 CLEANING AND PROTECTING

- A. Protect resinous flooring from damage and wear during the remainder of construction period. Use protective methods and materials, including temporary covering, recommended in writing by resinous flooring manufacturer.
- B. Clean resinous flooring not more than 4 days before dates scheduled for inspections intended to establish date of Substantial Completion in each Project area. Use cleaning materials and procedures recommended in writing by resinous flooring manufacturer.

1.3 3.05 RESINOUS FLOORING SCHEDULE

- A. Resinous Flooring: Provide resinous flooring system complying with the following:
 - 1. Material: Two coat epoxy resin composition flooring.
 - 2. Color and Pattern: As selected by Engineer from manufacturer's full range of colors and patterns produced for resinous flooring complying with requirements indicated.
 - 3. Total Thickness of Body Coat(s): 25 mm, unless otherwise indicated on Drawings.
 - 4. Wearing Surface: Antislip
 - 5. Base: 150 mm high integral cove base.
 - 6. Components: Provide manufacturer's standard components complying with requirements, unless otherwise indicated.
 - a. Chemical-resistant sealing or finish coat(s).
 - 7. Physical Properties: Provide resinous flooring system with the following minimum physical property requirements when tested according to standard test methods indicated:
 - a. Compressive Strength: 772 kg/cm².
 - b. Weight: 14.6 kg/m².
 - c. Impact Resistance: No chipping, cracking, or delamination and not more than 1.6-mm permanent indentation per MIL-D-3134.
 - d. Bond Strength: 100 percent concrete failure per ACI 503 R.
 - 8. Chemical Resistance: Test specimens of cured resinous flooring system are unaffected when tested according to ASTM D 543 , Procedure A, for immersion in the following reagents for not less than 7 days.

END OF SECTION
SECTION 09900

PAINTING

1. PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Painting materials complete with primers, sealers, stains applied for exterior and interior areas as indicated on Drawings and as specified in this section.

1.02 REFERENCES

A. FS - Federal Specifications

P-W-158E	Wax, General Purpose, Solvent Type
TT-E-489G	Enamel, Alkyd, Gloss (for Exterior and Interior Surfaces)
TT-E-506K	Enamel, Alkyd, Gloss, Tints and White (for Interior Use)
TT-E-509B(2)	Enamel, Odorless, Alkyd, Interior, Semi-gloss, White and Tints
TT-E-527C	Enamel, Alkyd, Lusterless
TT-E-543A(1)	Enamel, Interior, Undercoat, White and Tints
TT-F-336E	Filler, Wood, Paste
TT-P-19C(2)	Paint, Acrylic Emulsion; Exterior
TT-P-25E(2)	Primer Coating Exterior (undercoat for Wood, Ready-Mixed, White and Tints)
TT-P-29J(1)	Paint, Latex Base, Interior, Flat, White and Tints
TT-P-30E	Paint, Alkyd, Odorless, Interior, Flat, White and Tints
TT-P-37D	Paint, Alkyd Resin; Exterior Trim, Deep Colors
TT-P-52D(2)	Paint, Oil, (Alkyd-Oil) Wood Shakes and Rough Siding
TT-P-55B(2)	Paint, Polyvinyl Emulsion, Exterior
TT-P-81E	Paint, Oil, Alkyd, Ready-Mixed, Medium Shades
TT-P-641G(1)	Primer Coating; Zinc Dust-Zinc Oxide (for Galvanized Surfaces)

- | | |
|--------------|--|
| TT-P-645A | Primer Paint, Zinc Chromate, Alkyd Type |
| TT-P-650C(1) | Primer Coating; Zinc Dust-Zinc Oxide (for Galvanized Surfaces) |
| TT-P-664C(2) | Primer Coating, Synthetic, Rust-Inhibiting, Lacquer Resisting |
| TT-S-176E(1) | Sealer, Surface, Varnish Type, Floor, Wood and Cork |
| TT-S-300A | Shellac |
| TT-S-708A(2) | Stain, Oil, Semi-Transparent, Wood, Exterior |
| TT-S-711C | Stain, Oil-Type, Wood, Interior |
| TT-V-86C(1) | Varnish, Oil, Rubbing (for Metal and Wood Furniture) |
- B. SSPC - Steel Structures Painting Council
- | | |
|-----------|---------------------------|
| SP-6-63 | Commercial Blast Cleaning |
| SP-10-63T | Near-White Blast Cleaning |
- C. ASTM - American Society for Testing and Materials
- | | |
|------------|---|
| ASTM D 16 | Standard Definitions of Terms Relating to Paint, Varnish, Lacquer, and Related Products |
| ASTM D 562 | Consistency of Paints Using the Strometer Viscometer |
| ASTM D2833 | Standard Index of Methods for Testing Architectural Paints and Coatings |
- ASTM D3276 Standard Guide for Painting Inspectors (Metal Substrates)
- | | |
|------------|--|
| ASTM D3927 | Standard Guide for State and Institutional Purchasing of Plant |
| ASTM E 84 | Surface Burning Characteristics of Building Material |

1.03 SUBMITTALS

- A. Product Data: Submit manufacturers technical information including instructions for thinning, mixing, curing and touch-up.
- B. Manufacturer's standard color charts.
- C. Test Reports and certificates of compliance.

- D. Samples: Prior to beginning work, furnish color chips for surfaces to be painted. Submit samples for the Engineer's review of color and texture only. Provide a listing of material and application for each coat of each finish sample.
1. 300 mm x 300 mm hardboard, provide 2 samples of each color and material, with texture to simulate actual conditions. Re-submit samples as requested by the Engineer until acceptable sheen, color and texture is achieved.
 2. Wood surfaces, provide 2 samples 100 x 200 mm of natural and stained wood finish on actual wood types. Label and identify each as to location and application.
 3. Concrete masonry, provide two 100 mm square samples of masonry for each type of finish and color, defining filler, prime and finish coat.
 4. Actual wall surfaces and other exterior and interior building components, duplicate painted finishes of prepared samples. Provide full-coat finish samples on at least 9 m² of surface, as direct, until required sheen, color and texture is obtained; simulate finished lighting conditions for review of in-place work.
 5. Final acceptance of colors will be from samples applied on the job.

1.04 TRANSPORTATION, HANDLING AND STORAGE

- A. Deliver materials to job site in manufacturer's original new and unopened packages and containers bearing manufacturer's name and label, and following information:
- Name or title of material.
 - Manufacturer's stock number and date of manufacture.
 - Manufacturer's name.
 - Contents by volume, for major pigment and vehicle constituents.
 - Thinning instructions.
 - Application instructions.
 - Color name and number.
- B. Store materials not in actual use in tightly covered containers in a well-ventilated area and protect from moisture, direct sunlight and temperatures below 10°C and above limits recommended by the manufacturer. Maintain containers used in storage of paint in clean conditions, free of foreign materials and residue.

- C. Keep storage area neat and orderly. Remove oily rags and waste daily. Take all precautions to ensure that workmen and work areas are adequately protected from fire hazards and health hazards resulting from handling, mixing and application of paints.

1.05 QUALITY ASSURANCE

- A. Single Source Responsibility: Provide primers and other undercoat paint produced by same manufacturer as finish coats. Use only thinners approved by paint manufacturer, and use only within recommended limits.
- B. Coordination of Work: Review other Sections of these Specifications in which prime paints are to be provided to ensure compatibility of total coatings system for various substrates. Upon request from other trades, furnish information or characteristics of finish materials provided for use, to ensure compatible prime coats are used.
- C. Material Quality: Provide manufacturer's best quality trade sale paint material of various coating types specified. Paint material containers not displaying manufacturer's product identification will not be acceptable.

1.06 JOB CONDITIONS

- A. Do not paint when air is dust-laden or when weather and temperature conditions are unsuitable. Do not paint exterior surfaces in damp or rainy weather. Comply with manufacturer's recommendations with respect to application and drying period temperatures.
- B. Apply water-based paints only when temperature of surfaces to be painted and surrounding air temperatures are between 10°C and 32°C, unless otherwise permitted by paint manufacturer's printed instructions.
- C. Apply solvent-thinned paints only when temperature of surfaces to be painted and surrounding air temperatures are between 7°C and 35°C, unless otherwise permitted by paint manufacturer's printed instructions.
- D. Do not apply paint when relative humidity exceeds 85% or to damp or wet surfaces; unless otherwise permitted by paint manufacturer's printed instructions.

2. PART 2 - PRODUCTS

2.01 MATERIALS

- A. Material Quality: Paints, coatings, and primers shall be ready-mixed at the manufacturer's plant and shall be delivered in sealed containers, labelled and identified. Provide best quality grade of various types of coatings as regularly manufactured by acceptable paint materials manufacturers.

Paints and finishes shall have Class A rating in accordance with ASTM E 84. Materials without manufacturer's identification as a standard, best-grade product will not be acceptable. Use products of same manufacturer for succeeding coats.

- B. Color Pigments: Pure, non-fading, applicable types to suit substrates and service indicated.
- C. Color and Texture:
 - 1. Exterior Painting: Color and texture of the exterior paint shall be as indicated on Drawings and as approved by the Engineer.
 - 2. Interior Painting: Colors, textures, and degree of luster will be as indicated on Interior Design Drawings and Interior Design Specifications. Color selection will include safety colors for hazards in accordance with ANSI Z53.1 Safety Color Code for Marking Physical Hazards. Tint prime and undercoats approximately to the shade of the final coat but with sufficient variation to distinguish them from the preceding coat.
- D. Mildewcide: Paints shall contain a mildewcide as recommended by the manufacturer.
- E. Solvents and Thinners: As recommended by the paint manufacturer.

2.02 PAINTING SCHEDULE

- A. Exterior Paint Schedule:
 - 1. Concrete, Plaster, and Masonry - Smooth:
 - a. Prime Coat : Acrylic Solvent Based Primer.
 - b. Second Coat: Acrylic Copolymer Emulsion, Total Dry Film Thickness (DFT) 25 micron.
 - c. Finish Coat: Same as for Second Coat.
 - 2. Concrete, Plaster, and Masonry - Textured:
 - a. Prime Coat : Acrylic Solvent Based Primer.
 - b. Second Coat: Acrylic Copolymer Emulsion (Sprayed Applied), Dry Film Thickness (DFT) 50 micron.
 - c. Finish Coat: Acrylic Copolymer Emulsion Dry Film Thickness (DFT) 50 micron.
 - 3. Waterproof Painting System:

- a. Proprietary coating system consisting of synthetic rubber copolymer and suitable for external exposed application.
 - b. Prime coats and finish coat shall be applied as per the manufacturer's written recommendations for the intended application.
- 4. Ferrous Metals:
 - a. Prime Coat : Polyamide Cured Epoxy Primer, 50 micron (DFT).
 - b. Second Coat: High Build Epoxy, 125 micron thick (DFT).
 - c. Finish Coat: Two-Component Polyurethane, semi-gloss, 50 micron (DFT).
- 5. Zinc-Coated Metals:
 - a. Prime Coat : Acrylic Water Based Primer for GI.
 - b. Second Coat: Alkyd Enamel, semi-gloss, 30 micron (DFT).
 - c. Finish Coat: Same as for second coat.
- 6. Wood Paints:
 - a. Prime Coat : Alkyd Wood Primer + Wood Filler.
 - b. Second Coat: Alkyd Enamel, semi-gloss, 30 micron (DFT).
 - c. Finish Coat: Same as for second coat.
- 7. Natural Finish Wood:
 - a. Prime Coat : Alkyd Wood Stain.
 - b. Second Coat: Lacquer, semi-gloss, 25 micron (DFT).
 - c. Third Coat : Same as for second coat.
 - d. Finish Coat: Same as for second coat.
- B. Interior Paint Schedule:
 - 1. Concrete, Plaster, Gypsum Board, Reinforced Decorative Gypsum and Masonry:
 - a. Prime Coat : Acrylic Solvent Based Primer, flat.

- b. Second Coat: Acrylic Emulsion, Dry Film Thickness 25 micron (DFT).
 - c. Finish Coat: Same as for second coat.
- 2. Epoxy paint on cement screed floors and block and plaster walls:
 - a. Prime Coat : As per epoxy paint manufacture recommendation.
 - b. Second Coat: Two components polyamide cured epoxy paint with silica non-skid additive, Dry Film thickness 100 micron (DFT).
 - c. Finish Coat: Same as for second coat.
- 3. Ferrous Metals:
 - a. Prime Coat : Alkyd Primer.
 - b. Second Coat: Alkyd Enamel, semi-gloss, 30 micron (DFT).
 - c. Finish Coat: Same as for second coat.
- 4. Zinc-Coated Metals:
 - a. Same as specified for Exterior Paint Schedule.
- 5. Painted and Natural Finish Wood:
 - a. Same as specified for Exterior Paint Schedule.
- 6. Exposed Pipes, Ducts, and Metal work:
 - a. Prime Coat : Alkyd Primer.
 - b. Second Coat: Alkyd Enamel, semi-gloss, 30 micron (DFT).
 - c. Finish Coat: Same as for second coat.

3. PART 3 - EXECUTION

3.01 INSPECTION

- A. Examine substrate and conditions under which painting will be performed. Proceed with the work only when conditions are satisfactory.
- B. Do not paint over dirt, rust, scale, grease, moisture, scuffed surfaces, or

conditions otherwise detrimental to formation of a durable paint film.

3.02 SURFACE PREPARATION

A. General:

1. Remove hardware and accessories, machined surfaces, plates, lighting fixtures, and similar items in place and not to be finish-painted, or provide surface-applied protection prior to surface preparation and painting operations. Remove, if necessary, for complete painting of items and adjacent surfaces. Following completion of painting of each space or area, reinstall removed items.
2. Clean surfaces to be painted before applying paint or surface treatments. Remove oil and grease prior to mechanical cleaning. Program cleaning and painting so that contaminants from cleaning process will not fall onto wet, newly-painted surfaces.
3. Perform preparation and cleaning procedures in accordance with paint manufacturer's instructions and as specified in this section, for each particular substrate condition.
4. Fill dents, cracks, hollow places, open joints, and other irregularities with filler suitable for the purpose and, after setting sand to a smooth finish.
5. Prime surfaces not more than 8 hours after cleaning. Provide barrier coats over incompatible primers or remove and re-prime as required. Notify the Engineer in writing of any anticipated problems in using the specified coating systems with substrates primed by others.

B. Concrete, Masonry and Plaster Works: Prepare surfaces of concrete, concrete masonry cement plaster and gypsum plaster to be painted by removing efflorescence, chalk, dust, dirt, grease, oils, and by roughening as required to remove glaze. Use abrasive blast-cleaning methods if recommended by paint manufacturer and approved by the Engineer.

1. Determine alkalinity and moisture content of surfaces to be painted by performing appropriate tests. If surfaces are found to be sufficiently alkaline to cause blistering and burning of finish paint, correct this condition before application of paint. Do not paint over surfaces where moisture content exceeds that permitted in manufacturer's printed directions.
2. Clean concrete floor surfaces scheduled to be painted with a commercial solution of muriatic acid, or other etching cleaner. Flush floor with clean water to neutralize acid, and allow to dry before painting.

- C. Gypsum Board: Repair minor cracks and holes with finishing compound, and sand smooth after drying.
- D. Wood: Clean wood surfaces to be painted of dirt, oil, or other foreign substances with scrapers, mineral spirits and sandpaper, as required. Sandpaper smooth those finished surfaces exposed to view, and dust off. Scrape and clean small, dry, seasoned knots and apply a thin coat of white shellac or other recommended know sealer, before application of priming coat. After priming, fill holes and imperfections in finish surfaces with putty or plastic wood-filler. Sandpaper smooth when dried.
- E. Ferrous Metals: Clean non-galvanized ferrous-metal surfaces that have not been shop coated; remove mortar, plaster, grease, dirt, rust, loose mill scale and other foreign substances by solvent or mechanical cleaning methods that comply with the recommendations of the Steel Structures Painting Council, before priming coat is applied.
- F. Shop-Primed Ferrous Surfaces: Remove grease, oil and other foreign substances with approved type of cleaner manufactured for the purpose. Exercise care to prevent damage to shop coat. Touch-up abraded or marred shop coats with paint used for priming.
- G. Zinc-Coated (Galvanized) Surfaces: Remove grease and oil with a cleaner manufactured for the purpose. Treat surfaces with a chemical compound such as a phosphoric acid wash. Remove the chemical compound completely with clean, fresh water.

3.03 MATERIALS PREPARATION

- A. Mix and prepare painting materials in accordance with manufacturer's directions.
- B. Maintain containers used in mixing and application of paint in clean condition, free of foreign materials and residue.
- C. Stir materials before application to produce mixture of uniform density, stir as required during application. Do not stir surface film into material. Remove film and, if necessary, strain material before using.

3.04 APPLICATION

- A. Apply paint in accordance with the manufacturer's directions. Use applicators and techniques best suited for the type of material being applied. Do not exceed manufacturers recommended coverage per gallon. Apply materials with care to a uniform and proper film thickness, showing no runs, holidays, sags, crawls, or other defects. Apply with a minimum of brush marks. Finish surfaces shall be uniform in sheen, color and texture and match approved samples.
- B. Allow coats to dry thoroughly before succeeding coats are applied; allow a minimum of 24 hours between applications on any one surface unless otherwise specified by the paint materials manufacturer.

- C. Sandpaper undercoats on interior metal thoroughly and uniformly to provide a smooth, even surface for finish coats.
- D. Apply paint by brush, roller, spray, or other acceptable practice in accordance with the manufacturer's directions. Use brushes best suited for the type of material being applied. Use rollers of carpet, velvet back, or high-pile sheep wool as recommended by the paint manufacturer for material and texture required.
- E. Brush-out and work all brush coats into the surfaces in an even film. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, or other surface imperfections will not be acceptable. Neatly draw all primer or first coats, unless otherwise permitted to use mechanical applicators.
- F. Except as otherwise specified, apply a prime coat to material which is required to be painted or finished.
- G. Apply the first-coat material to surfaces that have been cleaned, pre-treated or otherwise prepared for painting as soon as practicable after preparation and before subsequent surface deterioration.
- H. Number of coats and paint film thickness required is the same regardless of the application method. Sand between each enamel and varnish coat application with fine sandpaper or rub surfaces with pumice stone where required to produce an even, smooth surface in accordance with the paint manufacturer's directions.
- I. Allow sufficient time between successive coatings to permit thorough drying. Do not re-coat until paint does not deform or feel sticky under moderate thumb pressure and the application of loss of adhesion of the undercoat.
- J. Paint type, color, surface treatment shall be as scheduled. Provide finish coats which are compatible with prime paints used.
- K. When undercoats, stains, or other conditions show through the final coat of paint, apply additional coats until the paint film is of uniform finish, color and appearance. Insure that all surfaces including edges, corners, crevices, welds, and exposed fasteners receive a film thickness equivalent to that of flat surfaces.
- L. Paint surfaces behind movable equipment and furniture the same as similar exposed surfaces. Paint surfaces behind permanently-fixed equipment or furniture with prime coat only. Exposed surfaces are defined as those areas visible when permanent or built-in fixtures, convactor covers, covers for finned tube radiation, grilles and similar items are in place in areas scheduled to be painted.
- M. Where visible through registers or grilles, paint interior surfaces of ducts and void spaces with a flat, non-specular black paint.
- N. Paint the back sides of access panels and removable or hinged covers to

match the exposed surfaces.

- O. Finish exterior doors on tops, bottoms and side edges the same as the exterior faces, unless otherwise indicated.
- P. Omit primer on metal surfaces that have been shop-primed and touch-up painted.
- Q. Dry Film Thickness: Provide dry film thickness for each finish type, including prime and finish coats, not less than total dry film thickness as specified in painting schedule.
- R. Stipple Enamel Finish: Roll and redistribute paint to an even and fine texture. Leave no evidence of rolling such as laps, irregularity in texture, skid marks, or other surface imperfections.
- S. Pigmented (Opaque) Finishes: Completely cover to provide an opaque, smooth surface of uniform finish, color, appearance and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, or other surface imperfections will not be acceptable.
- T. Transparent (Clear) Finishes: Use multiple coats to produce glass-smooth surface film of even luster. Provide a finish free of laps, cloudiness, color irregularity, runs, brush marks, orange peel, nail holes, or other surface imperfections. Provide satin finish for final coats, unless otherwise indicated.
- U. Completed Work: Match approved samples for color, texture and coverage. Remove, refinish or re-paint work not in compliance with specified requirements.

3.05 CLEAN-UP AND PROTECTION

A. Clean-Up:

- 1. During progress of work, remove from site discarded paint materials, rubbish, cans and rags at end of each work day.
- 2. Upon completion of painting work, clean window glass and other paint-spattered surfaces. Remove spattered paint by proper methods of washing and scraping, using care not to scratch otherwise damage finished surfaces.

B. Protection:

- 1. Protect work of other trades, whether to be painted or not, against damage by painting and finishing work. Correct any damage by cleaning, repairing or replacing, and re-painting, as acceptable by the Engineer.
- 2. Provide Wet Paint signs as required to protect newly-painted finishes. Remove temporary protective wrappings provided by others

for protection of their work, after completion of painting operations.

3. At completion of work of other trades, touch-up and restore damaged and/or defaced surfaces.

END OF SECTION

SECTION 09955

WALL COVERINGS

1. PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Surface preparation and adhesive prime paints.
- B. Resilient wall covering pad with final vinyl coating and wall fabric.

1.02 REFERENCES

- A. ANSI/ASTM E84 - Test Method for Surface Burning Characteristics of Building Materials.
- B. FS CCC-W-408 - Wall Covering, Vinyl Coated.
- C. FS L-P-1040 - Plastic Sheets and Strips, Poly vinyl chloride.
- D. NFPA 255 - Test of Surface Burning Characteristics of Building Materials.
- E. UL 723 - Tests for Surface Burning Characteristics of Building Materials.

1.03 QUALITY ASSURANCE

- A. Manufacturer: Company specializing in manufacturing commercial wall fabrics and coverings with 5 years documented experience.
- B. Applicator: Company specializing in installing wall fabrics and coverings with 5 years documented experience and shall be as approved by fabric and wall covering manufacturers and the Engineer.

1.04 SUBMITTALS

- A. Indicate on shop drawings, wall elevations with seaming layout.
- B. Provide product data for fabric, wall covering, adhesive and manufacturers standard systems.
- C. Submit two samples of fabric and wall covering 600 x 600 mm in size illustrating color, finish, and texture.
- D. Submit manufacturer's installation instructions and recommendations.
- E. Submit manufacturer's certificate showing that products meet or exceed the specified requirements.
- F. Submit test reports verifying flame/smoke ratings, when tested by UL or an agency approved by the Engineer.

1.05 FIELD MOCKUP

- A. Provide field samples, full height, illustrating installed fabric, wall covering, joint seaming technique and panel system where applicable for each different type of installation.
- B. Locate where directed by the Engineer.
- C. Accepted sample may not remain as part of the Work.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Inspect materials on site to verify acceptance.
- B. Protect packaged adhesive from temperature cycling.
- C. Storage and handling of fabric and resilient wall coverings as well as the related materials shall be in accordance with the manufacturer recommendation. Do not store roll goods on end.

1.07 ENVIRONMENTAL REQUIREMENTS

- A. Provide continuous ventilation and heating facilities to maintain substrate surface and ambient temperatures at 18 degrees C, unless required otherwise by the manufacturer instructions.
- B. Do not apply adhesive when substrate surface temperature, ambient temperature or humidity are not within the acceptable conditions recommended by the manufacturer.
- C. Maintain those conditions 24 hours before, during, and after installation of adhesive fabric and wall coverings.

2. PART 2 - PRODUCTS

2.01 MATERIALS

- A. Wall fabric Materials:
 - 1. Model and color shall be as indicated on Interior Design Drawings.
 - 2. Adhesive: Type recommended by wall fabric manufacturer to suit application to substrate.
 - 3. Substrate Filler: As recommended by adhesive and wall fabric manufacturer; compatible with substrate.
- B. Wall Covering Materials:

1. Resilient Wall Covering Vinyl Coating Material: Synthetic vinyl coat material, applied on wall covering pad of one or more coats of total thickness 2mm. Type and color shall be as recommended by wall covering manufacturer and as approved by the Engineer to suit intent of use.
2. Resilient Wall Covering Pad Materials: Resilient synthetic material, 20mm thick. Type shall be as recommended by wall covering manufacturer and as approved by the Engineer to suit final vinyl coating material and intent of use.
3. Adhesive: Type recommended by resilient wall covering manufacturer to suit application to substrate.
4. Substrate Filler: As recommended by adhesive and wall covering manufacturers; compatible with substrate.

3. PART 3 - EXECUTION

3.01 INSPECTION

- A. Verify that substrate surfaces are prime painted and ready to receive work, and conform to requirements of the wall covering and/or fabric manufacturer.
- B. Verify flatness tolerance of surfaces does not vary more 3 mm in 3 m nor vary at a rate greater than 1.5 mm per 300 mm.
- C. Beginning of installation means acceptance of existing surfaces and/or substrate.

3.02 PREPARATION

- A. Fill cracks and smooth irregularities with filler; sand smooth.
- B. Wash surfaces with a cleaning material recommended by manufacturer, rinse and neutralize; wipe dry.
- C. Remove electrical, telephone, and wall plates and covers.
- D. Vacuum clean surfaces free of loose particles.
- E. Apply 2 coats of primer sealer to substrate surfaces. Allow to dry. Lightly sand smooth. Vacuum clean.

3.03 INSTALLATION OF WALL COVERINGS AND/OR WALL FABRIC

- A. Apply adhesive and wall covering in accordance with manufacturer's instructions.
- B. Apply adhesive to wall surface immediately prior to application of wall covering.
- C. Razor trim edges on flat work table. Do not razor cut on wall surfaces.
- D. Apply wall covering smooth, without wrinkles, gaps or overlaps. Eliminate air pockets and ensure full bond to substrate surface. Butt edges tight.
- E. Horizontal seams are not acceptable.
- F. Do not seam within 50 mm of internal corners or within 150 mm of external corners.
- G. Install wall covering before installation of bases, cabinets, hardware, or items attached to or spaced slightly from wall surface. Do not install wall covering more than 6 mm below top of resilient base.
- H. Cover spaces above and below windows, above doors, in pattern or sequence from roll.
- I. Apply wall covering and/or fabric to electrical, telephone and wall plates prior to replacing.
- J. Where wall covering tucks into door frame reveals, or metal wallboard or plaster stops, apply covering with contact adhesive within 150 mm of wall covering termination. Ensure full contact bond.
- K. Install termination trim as required.

3.04 CLEANING AND PROTECTION

- A. Clean wall coverings and/or fabric of excess adhesive, dust, dirt, and other contaminants.
- B. Protect finished installation as directed by the Engineer.

END OF SECTION

SECTION 09960

HIGH-BUILD GLAZED COATINGS

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies a special coating (SC) system designed to provide on interior masonry or other surfaces a glazed tile like finish.

1.2 RELATED WORK

Location, color and texture (Class): Section 09 06 00, SCHEDULE FOR FINISHES.

1.3 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Samples:
 - 1. Material samples, 150 mm (six inches) square, showing the number of coats of each coating material on each substrate to which the material is to be applied. Apply coating to the samples in a setback procedure, leaving exposed a portion of the substrate and subsequent portions of each coat.
 - 2. Color samples, minimum 75 mm (three inches) by 125 mm (five inches) of each color and texture (Class) specified.
- C. Certificates:
 - 1. Certifying that the coating complies with requirements of this specification, including resistance to abrasion and resistance to perspiration.
 - 2. Certifying that the coating supplied is the same, with manufacturing tolerances, as the coating tested.
- D. Manufacturer's Literature and Data:

Literature and data describing the coating material to be furnished. Printed application for instructions for each substrate.
- E. Test Reports: Reports of tests certifying compliance with requirement specified.

1.4 ENVIRONMENTAL REQUIREMENTS

Apply coating only when surface and air ambient temperature is above 10⁰C (50 degrees F) and maintained for a period of not less than 48 hours after applications, except as otherwise required by the coating manufacturer.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. The Master Painters Institute (MPI):
Approved Product List – 2010

PART 2 - PRODUCTS

2.1 GLAZED COATING

- A. Epoxy Cold Cured Gloss: MPI No 77.

PART 3 - EXECUTION

3.1 PREPARATION OF SURFACES

- A. Patch surfaces as required for receiving glazed coating. Fill masonry block and make surfaces smooth and free of voids and pinholes. Assure surfaces are clean, dry, well cured, sound and free of ridges and depressions.
- B. Previous Coatings: Remove flaking, scaling or unsound coatings. Sand sound previous coatings to remain, with medium sand paper to eliminate gloss and provide tooth.
- C. Remove or protect items not requiring coating.

3.2 APPLICATION

- A. Finish Film Thickness: Apply materials at not less than the manufacturer's recommended spreading rate.
- B. On previously coated surfaces, apply one base coat and one finish coat.
- C. On bare concrete block and cast in place concrete apply two base coats and one finish coat.
- D. On bare gypsum board and plaster apply one primer coat, one base coat and one finish coat.

- E. In rooms or spaces shown or specified to have glazed coating, apply the glazed coating to surfaces behind casework and equipment, except behind those items built into wall recesses.
- F. Make edges of glazed coatings sharp and clean without overlapping adjoining other materials or colors.
- G. Apply glazed coating in areas specified under Section 09 06 00, SCHEDULE FOR FINISHES.

3.3 CLEANING AND PROTECTION

- A. During progress of the work and upon completion, promptly clean adjacent surfaces and materials of spills, spatters, drips, and stains from glazed coatings application. Remove glazed coatings by proper methods exercising care to prevent damage to finished surfaces and materials.
- B. Protect work of other trades against damage resulting from glazed coatings work.
- C. Touch up damaged coating surfaces before final acceptance.

END OF SECTION

**SPECIFICATIONS
FOR
ELECTRICAL WORKS**

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SECTION 01

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General Conditions, apply to work of this division.
- B. It's the Contractor responsibility to be fully aware of and comply with all of the requirements of the contract documents.

1.2 DESCRIPTION OF WORK

- A. Drawings are diagrammatic and are a graphic representation of contract requirements to the best available standards at the scale required.
- B. Light, power and systems riser diagrams and schematic diagrams generally indicate equipment connections to be used for various systems. Provide system raceway and wiring as required for actual systems installed on this project.
- C. Except where modified by a specific notation to the contrary, the indication and/or description of any item, in the Drawings of Specification or BOQ or all, carries with it the instruction to furnish and install the item complete with all appurtenances or accessories necessary to complete any required system, regardless of whether or not this instruction is explicitly stated as part of the indication or description.
- D. Specification, Drawings and Bill of Quantities are complimentary and are to be taken together for a complete interpretation of the work.
- E. Install the work in accordance with the diagrammatic intent expressed on the electrical and mechanical drawings, and in conformity with the dimensions indicated on final architectural working drawings and on equipment shop drawings.
- F. Certain details appear on the drawings, which are specific with regard to the dimensioning and positioning of the work. These details are intended only for the purpose of establishing general feasibility. They do not obviate field coordination for the indicated work.
- G. Where a discrepancy exists between the drawing and / or between drawings and other parts of the Contractor Documents or where the interpretation of either is in doubt, the Contractor shall obtain written clarification from the Engineer on such matters before commencing the Work.
- H. The following specifications detail the minimum performance and related criteria for electrical works. Any deviations from this specification must be documented in writing and submitted to the Engineer include but not limited to the deviated items with the magnitude of deviations with respect to the specifications.

1.3 PREPARATION OF CONTRACTOR'S WORKING DRAWINGS

- A. The contractor's working drawings shall be prepared by staff experienced in such work and the Contractor shall submit for Engineer review and approval evidence of the capability and experience of his staff who will undertake these tasks.
- B. The Design Drawings indicate the approximate position of equipment, etc., and the Contractor shall allow for any minor modifications to location that may be necessary.

1.4 COMMISSIONING AND PERFORMANCE TESTING

- A. Should the Contractor propose that the commissioning and performance testing be carried out by a specialist firm, full details of the capability and experience of such firm shall be submitted to the engineer for review and approval

1.5 CONDITIONS RELATING TO SUPPLIERS

- A. Submit a detailed list of manufacturers' names and addresses for materials and equipment proposed for the Work.
- B. Once accepted by the Engineer materials and equipment shall not be purchased from other sources without the prior written agreement of the Engineer.

1.6 SYSTEM MAINTENANCE CONTRACT

- A The Contractor shall submit a supplementary proposal for an annual system Maintenance Contract under which the Contractor would undertake, in addition to his obligations under this contract, to fully maintain the system in efficient working order, including routing checks, adjustments, lubrication and replacement of consumable spares, etc.,
- B. The proposal shall set out the terms of the offer, the work to be carried out, the guarantees of performance, the inclusive price for the twelve months following practical Completion, and terms under which annual maintenance may be carried out thereafter.

PART 2 - DEFINITIONS

2.1 GENERAL DEFINITIONS AND ABBREVIATIONS

- A. The following initials, words and phrases shall have the following meanings:
 - IEC - International Electro technical Commission
 - BS - British Standards
 - EN - European Standards.
 - NFPA - National Fire Protection Association
 - "IEE Regulations" - The Wiring Regulations for Electrical Installations within Buildings as issued by the IEE 16th edition.
 - "The work" - That part of the project dependent upon or

subsequent to the statement.

- | | | |
|------------------------|---|---|
| "The works" | - | The works referred to in the Specification and which are fully shown and described in the Contract Documents. |
| "Directed" | - | Directed by the Engineer |
| "Inspected" | - | Inspected by the Engineer. |
| "Submitted" or submit" | - | Submitted to or submit to the Engineer. |
| "Specification" | - | The description of performance requirements, materials and workmanship contained in the Contract Documentation. |

2.2 DEFINITION OF "AGREEMENT", ACCEPTANCE" AND "APPROVAL"

"Agreement", "Acceptance" or "Approval" by or of the Engineer shall have the following limitations:

- A. When given in respect to samples of materials, workmanship or methods of construction submitted in accordance with the requirements of the Contract Documents shall not be construed as denoting any degree of satisfaction with the materials used in, or the execution of the Works.
- B. When given in respect of drawings, documents or schemes called for by the contract Documents or proposed by the Contractor, is only for conformance with the design intent and information given in the Contract Documents or contained in subsequent Instructions.
- C. When given in respect to the methods of keeping records shall mean those methods are satisfactory.

2.3 SYMBOLS

- A. The symbol notation for all drawings to be produced by the Contractor shall be in accordance with applicable standards and regulations and shall be agreed by the Engineer and shown on a separate drawing.

PART 3 - DEFINITIONS OF TYPES OF ENGINEER'S DRAWINGS

3.1 TENDER DRAWINGS

- A. Shall mean the drawings prepared in such detail as may be necessary to enable those tendering to interpret the design for the Works and to submit competitive Tenders for the execution of the Works.

3.2 CONTRACT DRAWINGS

- A. Shall mean the drawings contained in or forming part of the numbered documents which constitute the Contract Documents.

3.3 TAKING DIMENSIONS FROM DRAWINGS

- A. The Contractor shall verify the accuracy of all dimensions abstracted from the contract drawings, including verifying the accuracy by taking dimensions on site, in the preparation of any drawings by the Contractor and before the relevant work proceeds.

3.4 DISCREPANCIES BETWEEN DRAWINGS

- A. Should any differences exist between the drawings or should there be any discrepancy in the figures, scale or the respects, the Contractor shall refer the same to the Engineer for clarification before proceeding with the work.

PART 4 - DEFINITIONS OF TYPES OF CONTRACTOR'S DRAWINGS

4.1 WORKSHOP DRAWINGS

- A. Shall mean the drawings, based on the Contract Drawings showing details of the Contractor's proposals for the execution of the Works. The drawings shall be 1:50, for floor plans and 1:25 for plant rooms and electrical rooms, in such detail and with all necessary dimensions as to enable the Work to be installed and shall indicate all conduit layouts, cable tray layouts, busway routing bends, connections etc., necessary for installation and also particular installation methods to be applied in certain instances, e.g. where connecting to utility services. These drawings shall also relate to builder's work drawings confirming relationships to, cable intakes.etc.
- B. Workshop drawings shall include but not necessarily be limited to:
 - i) General layout drawings of all plant and equipment included in the Contract.
 - ii) Schematics for main and sub-main distribution.
 - iii) Cabling and wiring connections showing cable types, sizes and loads.
 - iv) Trunking and cable tray routes with details of sizes, fixings, cables carried and terminations complete with calculations of trunking or tray Capacities .
 - v) Conduit routes with conduit sizes, methods of installation and details of cables, loads and terminations, and all junction and pull-in boxes.
 - vi) Power distribution for electrically operated equipments such as HVAC, PUMPS, motors, etc.
 - vii) Lighting layouts for normal, emergency and dimming purposes, detailing positions and types of luminaries, switch positions, wiring connections, dimming scheme, channels,etc..
 - viii) Earthing system with precise details of routing, conductor sizes, capacity and connection.
 - ix) Equipment arrangement mounting details power supply systems and changeover arrangements including detailed wiring with identification of those sections of the normal system operated from the standby source.

- x) Lightning protection system with precise details of position, routing, conductor sizes and terminations.
- xi) Fire detector and alarm positions and cable routes with type details and functions.
- xii) Communication systems equipment arrangement, mounting details, raceways and cable routes and details.

4.2 BUILDER'S WORK INFORMATION DRAWINGS

- A. Shall mean the drawings and Schedules prepared to show requirements for architectural or structural provisions necessary to facilitate the execution of the Works and allow their integration into the project.
- B. Such drawings should include requirements for foundations, bases, lifting and supporting structures for plant or equipment, all holes in walls, floors and ceiling elements, provision of services requirements within voids above false ceilings or below false floors, the integration of the services installations into the false ceiling system and trenches, depressions, ducts, etc., in or through building and site elements.
- C. General arrangements and floor plan drawings giving builder's work requirements shall be to a scale of 1:50.
- D. Builder's work drawings for plant rooms risers and electrical rooms shall be to a scale of 1:25.

4.3 MANUFACTURERS' AND EQUIPMENT DRAWINGS

- A. Shall mean the drawings of any item of plant or equipment produced by a manufacturer or equipment supplier indicating principle dimensions, fixings, connections and all other relevant details.
- B. Where manufactures' original drawings are used they shall be specific to the relevant Works and all references to optional features, other machines of a range, etc., shall be deleted or the original drawings redrawn to comply with this clause.
- C. Each drawing shall be stamped CERTIFIED by the Manufacturer which shall mean that:
 - i) The drawing represents accurately the item concerned with correct dimensions and all connections precisely located;
 - ii) The item conforms to the specific description given in the Documents, quoting the reference numbers from the Contract Document;
 - iii) The item is shown complete and entire as it will be supplied for the works and no extraneous or alternative parts are indicated;
- D. Individual and layout drawings from electrical component manufacturers shall include wiring internal and external to panels and controls.

- E. All wiring diagrams shall indicate clearly that wiring which forms part of or is connected to the equipment as delivered and shall include the following minimum information to enable the site connections and wiring to be completed:

- i) Maximum electrical loading for each power cable
- ii) Cable identification and all terminal numbers
- iii) Inter-connections between different items.

4.4 CONTROLS DRAWINGS

- A. Shall mean the drawings and schematics of plant and equipment showing the control layout with each item uniquely identified, and including a brief description of the controls operation and any associated interlocking.
- B. In respect of electric controls shall mean logic sequence and wiring diagrams showing the connections of all items of electric control equipment and interlocking on the plant control schematics.

4.5 SWITCHGEAR AND PANEL DRAWINGS

- A. Shall mean the drawings showing the general arrangement, the construction, the external and internal layout of panels, and wiring diagrams comprising internal wiring, schematics of interlocking and external wiring diagrams, for the complete systems in the panels.

4.6 RECORD DRAWINGS

- A. Before commencing work, provide complete set of coloured prints of Contract Drawings.
- B. Maintain prints in field office and permanently record, in colored pencil, on such prints, at time of occurrence, deviations from Contract Drawings.
- C. Dimension underground utilities from permanent identifiable structural points.
- D. Make drawings available for the Engineer 's periodic inspection and submit for review with As-Built Drawings.

4.7 AS-BUILT DRAWINGS

- A. Before commencing work, provide complete set of Contract Drawings on 4 mill Mylar and upon completion of works contractor shall submit on CD's, computer reproducible as built drawings of electrical works and colour prints.
- B. Neatly revise to conform with Record Drawings.
- C. Conspicuously indicate major deviations by specific reference to shop drawings and provide an accurate and complete record of the work as installed.
- D. Upon completion of work, submit signed and certified As-Built and referenced Shop Drawings, along with marked up prints of Record Drawings, to the Engineer for acceptance.

4.8 SCHEDULE OF DRAWINGS AND EQUIPMENT

- A. Prepare and submit before the relevant work proceeds, all drawings necessary to install the Works. Drawings shall be based on the Contract Drawings and must be fully coordinated with the architectural works and other disciplines and shall take into account any modifications either to the building or the installation which may have taken place, incorporating details of the actual items of plant and equipment to be installed.
- B. Prepare and submit all necessary Schedules of Equipment and devices with the relevant drawings.
- C. Prepare and submit schedule of light fittings and luminaries.
- D. The effect of any authorize variation or site instruction shall be carried through and shown on all applicable drawings by the Contractor. The cost of so doing shall be reimbursed to the Contractor as part of the cost of the variation of the instruction.

4.9 SIGNATURE ON CONTRACTOR'S DRAWINGS

- A. Each drawing submitted by the Contractor shall be signed by the Contractor to confirm that:
 - i) The work shown thereon has been coordinated both in sequence of installation and in physical relationship to the work of others.
 - ii) The drawing does not contain any variations other than those authorized by Engineer instruction.
 - iii) On re-submittal, all alterations made since initial submission have been clearly annotated on the drawing and listed separately down the right hand side of the drawing.

PART 5 - INFORMATION TO BE PROVIDED BY THE CONTRACTOR

5.1 GENERAL

- A. Submit to the Engineer a comprehensively detailed drawings showing all builders work required for the Works.
- B. Provide the Engineer with such information that may require on any matter related to or affecting the Works.

5.2 INFORMATION LISTED IN CONTRACT DOCUMENTS

- A. Submit to the Engineer all items of information required by the Contract Documents at the proper time so as not to impede the progress of the works.

5.3 INFORMATION FOR MANUALS

- A. Where the Contractor sublets the preparation of the Operation and Maintenance Manual to a specialist firm, the Contractor shall provide or obtain all necessary information in respect thereof.

5.4 MANUFACTURER'S TECHNICAL LITERATURE

- A. Manufacturers' technical literature submitted for examination or for inclusion in the Operation and Maintenance Manual shall be prepared and assembled specifically for the project and shall exclude any irrelevant matter. Each item shall be clearly identified on the record Drawings and cross-referenced to the contract Documents

5.5 MANUFACTURERS' GUARANTEES AND WARRANTIES

- A. All manufacturers' guarantees and warranties on plant, equipment, etc., shall be valid at least up to the end of the Defects Liability Period, or for at least twelve months after Practical Completion of the total project, whichever is the longer period.
- B. All equipment normally guaranteed by the manufacturers for a period of time, which goes beyond the period defined above, shall be held to remain under guarantee for the maximum period.
- C. Provide two copies of all such guarantees, one of which shall be included in the Operation and Maintenance Manual.

5.6 PLANT ROOM SCHEDULES AND SCHEMATICS

- A. In addition to the provision of Record Drawings, provide the following at a size to be easily readable and frame under glass and hang in each plant room and other appropriate location as directed by the Engineer.
 - a) Circuit diagrams consisting of schematic drawings of circuit layouts showing identification and duties of equipment, numbers and locations, control and circuits.
 - b) Control schematics.
 - c) Mechanical and electrical plant items.
 - d) First aid instructions for treatment of persons after electric shock.
 - e) All other items required under Statutory or other regulations.
 - f) Location of sprinkler fire main control valve.
 - g) Emergency operating procedures and telephone numbers for emergency call-out service applicable to any system or item of plant.

5.7 RELAY COORDINATION

- A. Submit to the Engineer a relay and C.B. selectivity study for the operation of full selective system.
- B. The Current-time characteristics must be plotted on a log-log papers showing that the choice of the C.B. settings are correct for selectivity coordination.

5.8 SHORT CIRCUIT AND VOLTAGE DROP CALCULATION

- A. Submit a comprehensive short circuit study as well as voltage drop calculation based on the actual impedance values of the electrical components such as (transformer per unit impedance, bus bars and cables impedance's ...etc) supply short circuit level at the 11KV shall not be less than 500 MVA,

PART 6 - OPERATION AND MAINTENANCE MANUALS

- A. Provide Operation and Maintenance Manuals (which shall incorporate Instruction Manuals on detailed requirements) covering and including the information detailed below:

6.1 SCOPE OF SYSTEMS

- i) A full technical description of each of the systems installed, written to ensure that the Owner's staff fully understand the scope and facilities provided.
- ii) A technical description of the mode of operation of all systems.

6.2 INSTALLATION RECORD

- i) A coloured photo of all Record Drawings together with an index.
- ii) Diagrammatic drawings of each system indicating principal items of plant, equipment, interconnections, etc.
- iii) Legend for all color-coded services.
- iv) Schedules of plant, equipment, by system, stating their locations within the building, duties and performance figures, together with anticipated life expectancies.
- v) A unique code for each item of plant, equipment, installed number cross-referenced to the record and diagrammatic drawings and Schedules. The name, address and telephone number of the manufacturer of every item of equipment and plant shall be listed together with catalogue list numbers.
- vi) Manufacturers' literature including detailed drawings, electrical circuit details, and printed operating and maintenance instructions for all items of plant and equipment supplied under this contract.
- vii) A copy of all test certificates including those for all plant, equipment, used in the installations, including (but not limited to) electrical circuit tests, corrosion testes, type testes, works tests, start-up and commissioning tests.
- viii) A copy of all manufacturers' guarantees.

6.3 SYSTEM OPERATION

- i) Starting up, operating and shutting down instructions for all equipment and systems installed.
- ii) Control sequences for all systems installed.

- iii) Scheduled details of all equipment settings, and actual values maintained in controlled variables during commissioning.
- iv) Procedures for seasonal changeovers.

6.4 MAINTENANCE

- i) Detailed recommendations as to the preventive maintenance frequency and procedures, including related health and safety procedures, which should be adopted by the Owner to ensure the most efficient operation of the systems. Specific details of maintenance procedures to prevent any hazard arising to health and safety shall be included.
- ii) Lubrication Schedules for all lubricated items of plant and equipment.
- iii) A set of normal consumable items.
- iv) A set of recommended "running spares" required, being those items subject to wear or deterioration and which may involve the Owner in extended deliveries when replacements are required at some future date.
- v) Procedures for full diagnosis.
- vi) Emergency procedures.

6.5 PREPARATION OF MANUALS

- A. The manuals shall be contained in A4 size, plastic-covered, lose leaf, four ring binders with stiff covers, each indexed, divided and appropriately cover-titled.

Drawings larger than A4 shall be folded and accommodated in the binder so that they may be unfolded without being in any detached from the rings.

- B. Prepare the Operation and Maintenance Manuals in draft as soon as the Installation Drawings are in hand.
- C. Make two sets of temporary manuals (with provisional Record Drawings and preliminary performance data) available at commencement of commissioning to enable Owner's staff to familiarize themselves with the installation.
- D. These should be of the same format as the final manuals with temporary insertions for items, which cannot be finalized until the works are commissioned, and performance tested.

6.6 OBLIGATIONS OF MANUFACTURERS TO PROVIDE LITERATURE

- A. The requirements and obligations of manufacturers to provide literature as part of the installation record shall form part of plant and equipment orders and such orders shall be considered unfulfilled until literature requirements have been met.

PART 7 - INSPECTION, TEST AND APPROVAL CERTIFICATES

7.1 GENERAL

- A. Submit Inspection, Test and Approval Certificates as required by the contract Documents.

PART 8 - PROVISION OF DRAWINGS AND DOCUMENTS

8.1 DRAWING PRODUCTION

- A. Prepare and submit a master plan for drawing production covering the following:
 - i) List of drawings to be produced
 - ii) Drawing/Schedule titles and numbers
 - iii) Symbols/notation/scales to be used
 - iv) Cross-references to other drawings
 - v) Identification of drawings required for record purposes.

8.2 CHECKING PRIOR TO SUBMISSION

- A. All drawings, Schedules and other information provided by manufacturers, suppliers, or approved sub-contractors shall be checked by the contractor who shall ensure that all requirements of the Contractor who shall ensure that all requirements of the Contract documents have been incorporated prior to submission.

8.3 PREPARATION OF RECORD DRAWINGS

- A. The preparation of the Record Drawings shall proceed during the installation of the Works as each section is completed. The Engineer shall be allowed to inspect these drawings on request during their preparation and each drawing shall be submitted to the Engineer prior to Practical Completion.

8.4 SUBMISSION OF OPERATION AND MAINTENANCE MANUAL

- A. The final draft of the Operation and Maintenance Manual shall be submitted in due time, and in any case not less than four weeks prior to Practical Completion, so that at least one copy of the complete final version is in the possession of the Owner at Practical Completion.
- B. the Operation and Maintenance Manual is an essential part of the works. The works will not be accepted as complete and payment will be withheld until the required number of copies of the complete final document has been received by the Engineer.
- C. If partial possession is required by the Owner then the documentation shall also be phased accordingly and so arranged to finally form one comprehensive document.
- D. It shall be the contractor's responsibility, whenever a successive phase of the works is handed over, to amend and update the previously issued version of the Operation and Maintenance Manual, bring it to the appropriate stage of completion and submit same to the Engineer in due time.

8.5 FAILURE TO PRODUCE RECORD DRAWINGS AND MANUALS

- A. If the contractor fails to produce and submit the record drawings as required during the progress of the works, or other information for the operation and Maintenance Manual by the due dates. then the Engineer

may instruct a third party to provide any or all of these documents and the total cost of preparing such documents shall be borne by the contractor.

PART 9 - CONTROL OF QUALITY

9.1 SPECIFIED MATERIALS, EQUIPMENT AND WORKMANSHIP

- A. Unless otherwise specified all materials, plant and equipment, and the use and installation thereof, shall comply with the material, test and other requirements of the relevant . IEE wiring regulations 16th edition and IEC standards.
- B. Materials or substances which are generally known at the time of use to be deleterious shall not be used other than as allowed by standards or statutory regulation current at the time of use
- C. Workmanship shall be of the best quality, and shall be produced by skilled and responsible craftsmen fully experience and in their respective trades.
- D. Allow for proper packing and safe delivery of all equipment and materials and for returning re-usable packaging to the suppliers as appropriate
- E. Include for obtaining materials from any source whatsoever to complete the works within the contract period and no claim will be allowed for materials ex-stock or from any other source in the event of difficulty of supply.
- F. Identical parts of similar equipment shall be interchangeable and any items, fittings or accessories which are used in quantity shall in each case be the produce of one manufacturer.

9.2 GUARANTEE AVAILABILITY OF SPARES

- A. Guarantee or provide manufacturers' written guarantees that spares will be available for a minimum period of ten years from the date of practical completion both to the Owner and to any other future building Owner, occupier or contractor having responsibility for the maintenance of the works.

9.3 PROTECTION OF MATERIALS AND EQUIPMENT PRIOR TO FIXING

- A. All installation materials, component parts or complete items of equipment shall be delivered and stored on site in properly labeled boxes, crates or containers, suitably designed and constructed to give protection against transportation and handling damage and deterioration during storage. The packing shall be weather-proof.
- B. Store all materials on raised boarded platforms under weather-proof cover, store, conduits, Trunking and the like on racking and store cables on drums.
- C. Equipment or component parts of equipment specifically designed to operate in normal room conditions, shall be delivered to and stored on site with suitable waterproof protection.
- D. Take particular care to protect component parts specifically designed to act as heat transfer surfaces. These surfaces shall have purpose-designed packing to protect them whilst in transit and storage on site.

- E. Examine all materials and equipment supplied under this contract on delivery to site and immediately prior to installation. Any material or equipment which is damaged or faulty shall be replaced.

9.4 SETTING OUT

- A. The contractor shall be responsible for the true and proper setting out of the works and for the correctness of position, levels, dimensions and alignment for all parts of the works and for the provision of all necessary instruments, appliances and labor in connection therewith. If any error shall appear or arise in the position, levels, dimensions or alignment of any part of the works the setting out for which the contractor was responsible, the contractor shall at his own expense rectify such error.
- B. The checking of any setting out or of any line or level by the Engineer shall not in any way relieve the contractor of his responsibility for the correctness thereof. The contractor shall carefully protection preserve all bench-marks, sight rails, pegs and other things used in setting out the works.
- C. Take all necessary dimensions on site, check runs and levels and mark out for builder's work.
- D. Any unnecessary work carried out by the Engineer or other contractor due to inaccuracy of the contractor's drawings, dimensions, or marking out shall be paid for by the contractor.

9.5 PROTECTION OF NEW WORK

- A. The contractor shall be entirely responsible for ensuring that all his work is adequately protected. Protection shall be by the contractor at the completion of each day and during periods of inclement weather, and all work exposed to view on completion in the works shall be protected from spillage, stains and other damage. All systems shall be kept in a fully drained condition prior to commissioning.

9.6 INSPECTION AND TESTING GENERALLY

- A. Agree procedures for notices, witnessing, reporting and recording tests with all parties involved including local authorities and statutory undertakings, prior to the commencement of the works.
- B. Submit copies of the formal test certificates signed by the contractor's representative not later than seven days after completion of successful tests.

9.7 ADDITIONAL TESTS

- A. Re-test or carry out at no extra cost any additional tests required to establish acceptability of the works following failure of any part thereof or any item therein to meet the required standard or functional performance.

9.8 INSTRUMENTS AND EQUIPMENT FOR TESTING

- A. Supply, check, re-calibrates whenever necessary and maintain in good working order all instruments and equipment for setting out, measurements, gauging, inspection, commissioning and performance testing whether they are specifically called for or implied by the contract documents.

- B. All such instruments and equipment shall be adequate for the purpose and shall satisfy the purposes and accuracy's required by the contract documents.
- C. All instruments and equipment shall remain the property of the contractor.

9.9 PROVISION OF STAFF

- A. Provide all necessary staff with the relevant skills and competence for all inspection, testing, commissioning and performance testing.

9.10 INSTRUMENTS AND EQUIPMENT FOR TESTING

- A. Provide assistance and make available to the Engineer any instruments or other equipment he may require from time to time for examining the accuracy, quality and performance of the contract works.

PART 10 - INSPECTION AND TESTING CERTIFICATES

10.1 PROCEDURES

- A. Schedule and submit an integrated program in respect of those elements of the works for which inspections and tests shall be carried out and for which inspection and test records shall be maintained.
- B. These elements shall include in particular those which will be covered up during construction, and other matters described under certificates for materials and equipment.
- C. Testing of individual items of plant and equipment at manufacturers' works shall be witnessed and approved by the Engineer. On site, and final testing of completed installations or parts of installations shall all be in accordance with the contract documents.

10.2 CERTIFICATES FOR MATERIALS AND EQUIPMENT

- A. All materials shall be manufactured and tested in accordance with the appropriate Standard or as described. Should the contractor propose an alternative item without the appropriate certification, independent testing shall be carried out at the contractor's expense to determine compliance with the contract documents.
- B. Where appropriate all materials delivered to the site shall bear the manufacturer's name, brand name and any other data that may be required to verify their exact nature and relate it to the requirements of the contract documents.

10.3 WORKS TESTS CERTIFICATES

- A. Works tests certificates shall include, full information to enable the item tested to be identified, such as project title, contractor's name, manufacturer's nameplate or serial numbers, the location in the works and the delivery or batch which the sample represents.

10.4 INSPECTION, AND TESTING RECORDS

- A. Maintain records of all inspections, and testing performed to substantiate conformity with the contract documents including those carried out by the

contractor and/or third party testing agencies, together with manufacturers' or suppliers' certificates of test.

- B. All records shall be retained on site and made available to the Engineer on request. On completion of the works all records shall be handed over to the Engineer unless otherwise directed.
- C. These records shall include, as appropriate, but not be limited to, project title, contractor's name, the identification of the element, item, batch or lot, the nature and number of the observations and tests, the dates of testing, the name and signature of the person responsible for the testing, the number and type of deficiencies found, and details of any corrective action taken.
- D. Any record which indicates that any part of the works inspected or tested does not comply with the contract documents shall be submitted without delay in order that the contractor's proposals for rectification may be assessed.

10.5 MATERIALS AND SAMPLES

- A. Each manufacturer must be willing to admit the Engineer and the consultant to his premises during normal working hours for the purpose of examining and witnessing the testing of materials and equipment proposed for the works.
- B. All materials and equipment shall be new.
- C. Obtain and implement manufacturers' instructions on the assembly and installation of materials and equipment.
- D. Submit all samples required by the contract documents.
- E. The procedure for submission of samples shall be agreed prior to commencement of the works.
- F. Samples of materials, workmanship, components and equipment accepted as complying with the contract documents will be retained by the consultant and all related items included in the works shall be at least equal in all respects to these samples.
- G. Provide safe storage of accepted samples on site including racks for display, reference and inspection.

10.6 REJECTION OF MATERIALS OR WORKS NOT TO STANDARD OF SAMPLES

- A. Any material or work which is inferior to an accepted sample or is different from parts of the works already constructed or which is stained or damaged after installation will be treated as defective work.

10.7 DEFECTIVE WORK

- A. Defective work, and the opening up of the works to ascertain same, shall be dealt with strictly in accordance with the requirements detailed elsewhere in the contract document.
- B. Replace defective work with materials, goods or work in accordance with the contract documents. Alternatively submit proposals for any treatment or making good that is considered will bring the defective work to the standard required by

the contract documents. Such proposals shall not relieve the contractor of his responsibility to execute the works to the full intent of the contract documents.

- C. The costs as defined in the contract conditions shall include the cost of any related delay or disruption in the progress of the works, or any other consequential cost.

10.8 DAMAGE BY INCLEMENT WEATHER

- A. The contractor shall not execute any work when it is likely to be adversely affected by inclement weather and he shall make good any damage so caused at his own expense.

PART 11 - COMMISSIONING THE WORKS

- A. All pre-commissioning checks, setting to work, commissioning and performance testing shall be carried out as detailed elsewhere in the contract documents.

11.1 ATTENDANCE AND CO-OPERATION

- A. give at least seven days' notice to the Engineer of requirements for the attendance and co-operation by the Main Contractor and by other contractors.

11.2 NOTICE TO ENGINEER

- A. Give at least seven days' notice to the Engineer of any commissioning or testing to be carried out to enable the Engineer to witness all or any of such tests, etc.

11.3 UNSUCCESSFUL TESTS

- A. The contractor shall pay any costs incurred by the Owner or Engineer in connection with unsuccessful tests, including costs incurred due to the inability of the contractor to make or complete a test, having given the notice required above.

11.4 CHECKING AND COMMISSIONING

- A. Commissioning includes the setting to work and regulation of the installation.
- B. Check all installations and commission in accordance with the contract documents including but not limited to the following :
 - i. Co-operation with the Engineer to produce a coordinated program for the testing and commissioning of the complete works.
 - ii. Provision of all consumable materials.
 - iii. Provision of such temporary communication apparatus as is necessary to enable members of the commissioning team who are unable to be in visual or aural contact with each other to carry out their tasks safely and effectively. Such apparatus shall not cause interference with equipment owned or operated by any other parties.
 - iv. Provision of proper and permanent records of relevant readings of all quantities taken during the checking, pre-commissioning and commissioning procedures.

The form of the records shall be agreed with the Engineer in advance of commissioning and the record for each complete commissioning procedure

shall be dated and signed by the person whom the contractor has appointed to be formally in charge of commissioning.

11.5 PERFORMANCE TESTS

- A. When the Contractor has completed the commissioning of the whole of works he shall give to the Engineer written certification of this fact. The certificate shall be signed by the director or manager responsible for the contract.
- B. Only when this written certification has been received by the Owner's authorized representative will performance tests be allowed to commence. Unless otherwise agreed by the Engineer in writing, where engineering systems involve the works of more than one works contractor, performance tests will only be allowed to commence when written certification from all the relevant works contractors has been received.
- C. Carry out during this period full tests on the complete works to demonstrate that the works meet the requirements of the contract documents.

11.6 RECORDS OF WEATHER CONDITIONS

- A. Keep a daily record throughout the contract period of the maximum, minimum and average outside shade temperature, humidity and wind speed.

11.7 SUMMER AND WINTER PERFORMANCE TESTS

- A. Test the performance of the whole of the works in both summer and winter design conditions and allow for any special visits to site and provide any necessary attendance during the defects liability period to set up, monitor and remove test and recording equipment.

11.8 SYSTEMS USED BEFORE PRACTICAL COMPLETION

- A. No part of the permanent services installations shall be used by the contractor for his own benefit without the written agreement of the Engineer..
- B. Should any part of the works be operated during the period of the contract for the benefit of the contractor and/or the Engineer, all consumable spares, including light bulbs and tubes which have been so put to use shall be replaced by new not more than seven days prior to practical completion.

11.9 DEFECTS LIABILITY

- A. Defects, shrinkage's or other faults appearing at any time during the defects liability period which have led, or, in the opinion of the Engineer, are likely to lead to failure or malfunction of any part of the works shall be made good immediately upon receipt of any instruction or direction of the Engineer.
- B. Prepare and submit a record of any failure or malfunction of any part of the works, the remedial action taken, subsequent re-testing and the results thereof.
- C. Notify the Engineer of any malfunction in, or damage to, the works which the contractor can demonstrate had been caused by incorrect operation of the system, vandalism or action of a third party.

- D. Inform the Engineer in writing when all defects are finally rectified so that an inspection may be carried out prior to the issue of the final certificate.

PART 12 - INSTRUCTING THE OWNER'S STAFF IN OPERATION OF SYSTEMS AND EQUIPMENT PRIOR TO PRACTICAL COMPLETION

- A. Prior to practical completion of the installation, the Owner will be appointing maintenance staff or maintenance contractor to undertake the operation and maintenance of the building services installation.

The contractor shall include for providing assistance to the Owner's staff during the course of the installation to explain the purpose and function of the works.

- B. Include for a minimum period of 25 plant operating days prior to practical completion, to instruct the Owner's maintenance staff or maintenance contractor in the day to day running of the plant and systems. The location and function of all items listed on the record schedules shall be explained and the procedures given in the operating and maintenance manuals for starting up, shutting down, isolating sections, emergency procedures, etc., shall be comprehensively explained and demonstrated to the Owner's satisfaction.

PART 13 - SPARE PARTS AND TOOLS

13.1 SPARE PARTS

- A. Prior to practical completion, submit a schedule of the additional spare parts that the contractor recommends should be supplied over and above those consumable spares required up to practical completion and for routine maintenance.
- B. Each item on the schedule shall have the manufacturer's current price inserted, which shall also include for packaging and delivery to site.
- C. These additional spare parts may or may not be ordered during the currency of the contract and therefore the cost thereof shall only be included in the contract sum when the subject of an instruction by the Engineer.
- D. Spare parts shall be completely interchangeable and suitable for use in place of the corresponding part supplied with the plant. They shall be greased and/or painted before packing to prevent deterioration during delivery and storage.
- E. Where spare parts are supplied by the contractor, each package shall be clearly marked and numbered for identification in accordance with the schedule of spare parts and referenced to the equipment list in the operation and maintenance manual.
- F. Spare parts shall be handed over to the appointed representative of the Owner.

13.2 TOOLS

- A. At practical completion, provide two complete sets of tools and portable indicating instruments for the operation and maintenance of all plant and equipment together with suitable means of identifying, storing and securing same.

PART 14 - FUEL AND POWER FOR COMMISSIONING

- A. Fuel and power for commissioning and performance testing the works including payment of statutory undertakings for same.
- B. Fuel, water and power for running the contract heating system to dry out the building including payment of statutory undertakings for same.

PART 15 - SCOPE OF WORKS

15.1 THE CONTRACT WORKS

- A. The works covered by this contract are the selection, manufacturing, works testing, supplying and delivery to site, erecting, connecting up, testing, commissioning, performance testing and handing over in working order the complete engineering services installations, as described in the contract document.

15.2 SYSTEMS INCLUDED

- 1. Emergency diesel generator.
- 2. Low voltage switchgears.
- 3. Distribution panel boards.
- 4. Low voltage wires and cables.
- 5. Lightning protection.
- 6. Earthing system.
- 7. Raceways for lighting, sockets, power, low current, communication and miscellaneous electrical operated systems or equipment.
- 8. Wiring devices (switches, sockets,...etc).
- 9. Motor control centers.
- 10. Switch disconnectors (isolators).
- 11. Lighting fixtures.
- 12. UPS systems.
- 13. IT systems.

PART 16 - RELATED WORK

There will be other Works associated with and related to this Contract the contractor is responsible to get the approval from other related contract authorities.

The Contractor shall make himself fully aware of the interfaces between and the requirements of his Works and the works of other.

The Contractor shall, before commencement of Installation Drawings, make himself fully aware of the special setting-out and installation requirements of other contract Works that affect the Works of this Section.

PART 17 - TESTING AND COMMISSIONING

- A. The contractor shall be required to demonstrate that the equipment and systems under this Contract function and operate in full accordance with the Specification and the testing and commissioning procedures described elsewhere in this Specification.
- B. Once the Contractor has demonstrated the operation of the Works to the satisfaction of the Engineer the complete integration of the Contractors Works with the Works of others will be the responsibility of others.

- C. Notwithstanding this, the Contractor's Works will not be deemed complete until the works are fully integrated and demonstrated in function and operation as being fully integrated with the associated works by others.
- D. The Contractor shall allow for full attendance to the Engineer and others in order that the whole of the Works under this contract can be successfully demonstrated to be functioning and operating with all other associated works to the satisfaction of the Engineer..
- E. This shall not relieve the contractor in any way of his responsibilities under the Contract.

END OF SECTION 01

SECTION 02

EARTHING SYSTEM

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and General requirements apply to work of this section.
- B. Basic electrical materials and methods, section 16050 applies to work of this section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services and tests necessary to complete and make ready for operation, the earthing system work in accordance with Drawings and Specifications and as required for a complete system.

1.3 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in the manufacture of earthing products, of types, and ratings required, and ancillary materials, including stranded cable, copper braid and bus and bonding jumpers whose products have been in satisfactory use in similar service for not less than 10 years.
- B. Standards Compliance: Comply with requirements of applicable local codes, IEC 61364 – 5 and IEE wiring regulations 16th edition pertaining to electrical earthing system and equipment.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's data on earthing products and associated accessories.
- B. Samples: Submit sample of earthing cables and earthing accessories.
- C. Shop drawings: Submit dimensional layouts on architectural background drawings.
- D. Calculations: submit detailed calculations verifying the earth resistance value considering the soil conditions.

PART 2 - PRODUCTS

2.1 RECOMMENDED MANUFACTURER

Refer to list of recommended manufacturers.

2.2 ELECTRODES

- A. Earthing system will be provided for the earthing of the entire development including the M.V switchgears, L.V switchgears, transformers, generator set, panel boards, electrical circuits, building structure, bonding...etc and associated equipments.
- B. Earthing rods will be installed as indicated in the drawings with cable connection to earthing equalizer / bars.
- C. Earth rods shall be of circular cross-section copper bond type and as indicated shall be jointed with purpose made couplings and a suitable driving cap and tip shall be fitted to the rod. Couplings shall not exceed the diameter of the rod.
- D. Rod section couplings, driving cap and tip shall be bronze or other material, which exhibits mechanical strength, electrical continuity between sections and does not give rise to electrolytic or corrosive action. All coupling units shall be the same length of threaded length of the rod.
- E. Earth rods shall be a minimum length of 3 meters $\frac{3}{4}$ " inch diameter and shall be driven into the ground using a suitable mechanical hammer. The tops of the rods shall be driven below ground level to suit the inspection pit.
- F. The top of each rod electrode shall be housed in a purpose made concrete pit to facilitate inspection. The pit shall be provided with a lid and the assembly shall be flush with ground level.
- G. Earth pits installed below ground level shall be provided with a waterproof seal.
- H. Parallel connected earth rods shall be spaced at a horizontal distance equal to their buried length. They shall be connected with bare stranded copper cable unless otherwise shown on the drawings, buried not less than 750 mm below ground level unless otherwise shown on the drawings.
- I. Copper strip or stranded cable may be installed in the same trenches as M.V/LV cables but shall be separated from all other cables and services by a distance not less than 300 mm.
- J. The resistance to earth of the electrode system for power services shall not exceed three ohms and for communication services shall not exceed half ohm. Site testes shall be made to ascertain that the electrode system resistance meets this requirement. If the resistance exceeds this figure the contractor shall provide the necessary materials to reduce the system resistance to the specified level.

2.3 EARTHING CONDUCTORS

- A. Earthing conductors connecting the main earthing terminal or bar and electrode system shall be green/yellow PVC insulated, stranded copper cable. A minimum of two earthing conductors shall be installed and separately connected to the main earth bar with bolted test links of copper and having a cross section equal to the main earth bar.

2.4 MAIN EARTHING TERMINAL

- A. The main earthing terminal shall consist of hard drawn copper formed into a bar having minimum dimensions as detailed in the earthing schematic.
- B. Each earthing bar shall be mounted not less than 600 mm above the finished floor level and spaced by means of insulators not less than 50 mm from the fixing surface.
- C. The diameter of fixing holes shall not exceed one third of earthing bar width. Where this is not possible then the connection shall be made to a copper flag welded to the earthing bar.
- D. Each connection to the main earthing terminal shall be identified with an appropriately worded label made of durable material.

2.5 PROTECTIVE CONDUCTORS

- A. Protective conductors between equipment earthing terminals or bars and the main earthing terminal or bar shall be made with stranded copper insulated cables as shown on the drawings. Cables shall be connected to remote ends of the equipment earthing terminals or bar and separately connected to the main earthing terminal or bar.
- B. Where a number of protective conductors follow the same route these shall be green/yellow PVC covered and installed on a cable tray and fixed with purpose made cleats.
- C. Connections between main earthing terminal or bars, equipment earthing terminals, etc, and stranded copper cables shall be made with appropriate compression type lug, bolt, nut and lock washers. Contact surfaces shall be thoroughly cleaned and tinned.
- D. Sockets lugs, bolts, nuts, washers, screws, rivets, clamps, cleats or other items which come into direct contact with copper protective conductors bars, strips, cables etc, shall be non-ferrous and manufactured from brass, bronze or other suitable conducting material which will not cause electrolytic or other corrosion. Where connections occur between copper and galvanized structures, contact surfaces shall, additionally, be tinned and after completion compounded to exclude moisture. Protective conductors, cables, strip, bars, lugs, etc, shall be installed in visible and serviceable positions.
- E. The joints shall be made using zinc free brazing material with a melting point of at least 600 °C. The amount of overlap between the two strips to be jointed shall not be less than the width of the larger conductor.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions under which electrical earthing connections are to be made and notify in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install electrical earthing system as indicated in accordance with manufacturer's instructions, requirements of applicable standards, and in accordance with recognized industry practices to ensure that installation complies with requirements and serves intended function.
- B. Coordinate as necessary to interface installation of electrical earthing system work with other work.
- C. Earth the electrical installation including, but not limited to, the following: Underground distribution, substation service equipment, electrical service system, switchgear housings, cabinets, housings and neutrals of transformers lightning protection system, emergency distribution systems, busway enclosures, motor control centers, individual starters cable trays, cable trunkings and other non-current carrying metal parts of electrical equipment.
- D. Wherever flexible metal conduit or cable are used for part of a raceway run, provide an earthing conductor in the raceway or cable and connect to earthing bushings at each end of run.
- E. Where pull boxes contain barriers, provide an earth lug in each section.
- F. Install earthing conductors in all circuits wiring.
- G. Terminate feeder and branch circuit insulated equipment earthing conductors with earthing lug, bus, or bushing.
- H. Route earthing connections and conductors to earth and protective devices in shortest and straightest paths as possible to minimize transient voltage rises.
- I. Install clamp-on connectors on clean metal contact surfaces, to ensure electrical conductivity and circuit integrity.
- J. Where expansion fittings occur, provide internal earth conductor terminating in adjacent pulling points with earthing bushings.
- K. Metallic pipe services for example, gas mains, water mains and dry risers shall be effectively bonded to the main earthing terminal at their point of entry. Connections shall be made to the services with purpose-made earthing clamps.
- L. Where there is a lightning conductor system for the building or structure, it shall be effectively bonded to the main earthing terminal. A suitable label shall be provided adjacent to this bonding connection at the main earthing terminal indicating the purposed of connection.
- M. Building structures shall be effectively bonded to the main earthing system (Grid).
- N. The cross-sectional area of all earthing, bonding and protective conductors shall comply with the requirements of the IEE wiring regulations. Except

where detailed otherwise in this specification or on the drawings all conductors for earthing shall be copper.

- O. Single-core cables forming part of the earthing system shall be of stranded copper, with green/yellow PVC.
- P. Mechanical joints between aluminum and copper shall have the joint faces lightly coated with an anti-corrosion compound before the connection is made.
- Q. Where conduits, or glands for armoured cables, terminate on switchgear, distribution boards, starter panels or other apparatus then brass compression washers shall be used to ensure an effective earth connection.
- R. Where connections are made between sections of raceways then the manufacturer's earth continuity links shall be installed across the joint. Connections made between raceways sections crossing a building expansion joint shall be made with a flexible copper braid.
- S. Sections of cable tray shall be thoroughly cleaned before overlapping and securing with a minimum of two screwed fixings. The remote ends of the cable tray shall be effectively bonded to the earthing system.
- T. The armouring of plastic sheathed cables shall terminate in compression glands fitted with purpose-made earth tags. A protective conductor shall connect the earth tag with the apparatus earthing terminal. The earth tag shall be manufactured from a high conductivity material compatible with the cable gland.
- U. The armouring of metal sheathed cables shall be securely clamped to the gland at the cable termination with a purpose-made bolted clamp. A protective conductor shall be installed to connect the armour clamp or gland fixing bolts to the apparatus earthing terminal.

3.3 EARTH TESTS

- A. After installation of the individual earthing systems in accordance with the above for the various parts of the works and after the whole installation has been connected up, resistance tests shall be carried out at each sub-station and for each earth source independently and the readings obtained officially and recorded. Three readings shall be obtained for each sub-station relating to the two earth paths connected individually and in parallel.
- B. An Ever shed and Vignoles or similar earth tester shall be used and all results tabulated and handed to the Engineer.

3.4 FIELD QUALITY CONTROL

- A. Upon completion of installation of electrical earthing, test ground resistance with ground resistance tester.
- B. Weld earthing conductors to underground earthing electrodes.
- C. Earth electrical service system neutral at service entrance equipment to earthing electrodes.

- D. Earthing each separately-derived system neutral to:
 - a. Effectively earthed metallic water pipe.
 - b. Effectively earthed structural steel member.
 - b. Separate earthing electrode.

END OF SECTION 02

SECTION 03

ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions (General requirements), apply to work of this section.
- B. Basic electrical materials and methods, section 16050 applies to work of this section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, and services to complete and make ready for the Owner, the identification of all electrical equipment as required by this section and other sections of the specifications. This includes, but is not limited to buried cable warning, power, control and communication conductors, operational instruction and warnings; danger signs, and equipment system identification signs.

1.3 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in manufacture of electrical identification products of types required whose products have been in satisfactory use in similar service for not less than 10 years.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's data on electrical identification materials and products.
- B. Samples, complete with nomenclature for the following:
 - 1. Engraved lamacoid plates of each size of lettering.
 - 2. Wraparound labels.
 - 3. Metal tags.
 - 4. Enameled sheet metal signage.

PART 2 - PRODUCTS

2.1 LAMACOID NAMEPLATES

- A. Identification for power centers, switchboards and panelboards: Engraved lamacoid nameplates with 6 mm high white lettering on black background fastened to the outside face of the front.
- B. Identification for switch disconnectors or circuit breakers of the following:
 - 1. For Individually Enclosed Units: Engraved lamacoid nameplates with 3 mm high white lettering on a black background fastened to outside front face of enclosure.

2. For Panelboards With Doors: Typewritten directories mounted behind transparent plastic cover, in metal frames fastened on inside face of doors; directories to indicate circuit number, designation of room and number and item being served in directories.

2.2 WRAPAROUND LABELS AND METAL TAGS

- A. Identify the wires and cables of feeders by means of fiber or non-ferrous metal tags fastened with non-ferrous metal wires or bands throughout; fastenings for metal tags of the same metal as the tag.

2.3 ENGRAVED LETTERING

- A. Engrave device plates for local toggle switches, toggle switch-type motor starters, pilot lights, and the like, whose function is not readily apparent with 3mm high letter suitably describing the equipment controlled or indicated.

2.4 STAMPED LETTERING

- A. Stamp phase identification letters into the metal of the bus bars of each phase of the main busses of each power center switchboard and panelboard; make letters visible without having to disassemble any current carrying or supporting elements.

2.5 IDENTIFIABLE MARKINGS

- A. Identify each outlet box, junction box and cabinet used in conjunction with empty raceway for wires of a future system by means of identifiable markings on the inside denoting the system.

2.6 ENAMELED SHEET METAL SIGNAGE

- A. Equip all electric switchboard rooms, electric closets, metal screened spaces assigned to electric equipment and the like, with enameled sheet metal "red on white" signs reading "Electric Equipment Room - No Storage Permitted"; mount signs at clearly visible locations within the rooms.

2.7 PORCELAIN ENAMEL RED ON WHITE

- A. Mark all outdoor substations with porcelain enamel red on white reading "Danger - High Voltage" and in accordance with Utility Company requirements.

2.8 ENGRAVE

- A. Device plate for receptacles other than 220 volt 10 and 16 amperes receptacles with 3 mm high black letters and designating the following:
 1. Voltage
 2. Number of phases
 3. Current rating.
- B. Device plates for receptacles on emergency, engraved "EMERGENCY" as described in Section 16140.

2.9 MARK

- A. Cabinets housing emergency lighting and receptacle panelboards with the word "EMERGENCY" stenciled in 5 cm high red letters on the outside of the cabinet, in addition to other lettering and nameplates required above.

2.10 NOMENCLATURE

- A. The nomenclature used to identify power centers, dimmer boards, switchboards and panelboards to match the nomenclature used on the drawings.
- B. The nomenclature used to identify switched or circuit breakers to:
 - 1. Designate where they disconnect mains or service together with suitable differentiating nomenclature where more than one service or main is involved.
 - 2. Designate the feeder number and the name of the load supplied where they control feeders.
 - 3. Designate the name of the space and the load supplied where they control lighting and appliance branch circuitry.
- C. The nomenclature used to identify feeder wires and cables to designate the feeder number.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which electrical identification products are to be installed. Notify Engineer in writing of conditions detrimental to proper completion of the work.
Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install electrical identification products as indicated, in accordance with manufacturer's written instructions, requirements of applicable Standards, and in accordance with recognized industry practices to ensure that installation complies with requirements and serves intended function.
- B. Coordinate as necessary to interface installation of electrical identification products with other work.
- C. Comply with governing regulations and requests of governing authority for identification of electrical work.
- D. Wherever reasonably required to ensure safe and efficient operation and maintenance of electrical systems and electrically connected mechanical systems and general systems and equipment, including prevention of misuse

of electrical facilities by unauthorized personnel, install signs or similar equivalent identifications, instruction or warnings on switches, outlets and other controls, devices and covers of electrical enclosures. Where detailed instructions or explanations are needed, provide plasticized tags with clearly written messages adequate for intended purposes.

- E. Install signs at location for best convenience of viewing without interference with operation and maintenance of equipment. Secure to substrate with fasteners, except use adhesive where fasteners should not or cannot penetrate substrate.
- F. Securely fasten signage and nameplates.
- G. Identify each wire or cable in a feeder at its terminal points of connection and in each handhole, pull box, junction box and panel gutter through which it passes.
- H. Label all conductors in wireways and pull and junction boxes with panelboard designations and circuit number.
- I. Identify Individually:
 - 1. Switchgears.
 - 2. Transformers.
 - 3. Standby generator set.
 - 4. Panel boards.
 - 5. Devices in switchboard and panelboards.
 - 6. Switch Disconnectors.
 - 7. Cables.
 - 8. Cabinets, junction and pull boxes of all systems installed.
 - 9. Cable trays and trunkings.

END OF SECTION 03

SECTION 04

LOW VOLTAGE WIRES AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions (General requirements), apply to work of this section.
- B. Basic electrical materials and methods, section 16050 applies to work of this section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all wires, cables and connections, complete with all accessories in accordance with Drawings and Specifications and as required for a complete system. Wiring size referenced in this Section is metric, except as noted. For special wiring for individual systems, refer to respective Section of these Specifications.

1.3 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in manufacture of wires, cables, and connections of types, sizes and ratings required, whose products have been in satisfactory use in similar service for not less than 10 years.
- B. Standards Compliance: Comply with requirements of applicable local codes, IEC 60502 pertaining to wires, cables and connections.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturers' data on wires, cables and connectors.
- B. Samples : Submit 25 cm length cables of each type and size of wires and Cables, Manufacturer Name, insulation class and reference No. Should be indicated on the Submitted Sample.

PART 2 - PRODUCTS

2.1 RECOMMENDED MANUFACTURERS

Refer to list of recommended manufacturers.

2.2 LOW VOLTAGE CABLES

A. GENERAL

- 1. Provide all of the mains low voltage cables shown on the drawings or detailed in the cable schedules.
- 2. All cables shall comply with IEC 60502 and all conductors shall be copper P.V.C. insulated and P.V.C. sheathed (0.6/1 K.v).

3. Copper conductors shall be stranded for sections 2.5 mm^2 , and above. Signal and control cables shall have solid conductors. Flexible cords shall have finely stranded conductors.
4. Conductor sizes shall be metric, as shown on the Drawings. Conductors with cross-sectional areas smaller than specified will not be accepted.
5. The current carrying capacity of conductors have been determined in accordance with the IEE wiring Regulations 16th edition for the specified type of insulation and the expected conditions of installation. No change will be accepted in the specified type of insulation, unless warranted by special conditions and approved by the Engineer.
6. The insulation of each conductor shall be colour coded or otherwise identified as required by the Regulations. Colour coding shall be maintained throughout the entire installation.
7. For each lot of cable supply a certificate of origin issued by the manufacturer stating its origin, manufacturer, constitution and standards to which it complies with. In the absence of such documents, the Engineer reserves the right to require that tests, at the Contractor's expense, be performed by an official laboratory on samples taken from lots of cables delivered to the Site.
8. Cable installations whether so indicated or not shall include all joints and their accessories at terminating ends or at tap-off points, earthing and bonding etc. Carried to completion.
9. Joints in cable shall not be accepted. Cables shall be supplied in lengths sufficient for a straight-through pull from termination to termination.
10. All cables shall be delivered to site with the manufacturer's seals, labels, or other proof of origin intact. Such labels and seals shall not be removed until the cable is required for use, and shall be retained for inspection.
11. Unless otherwise specified herein or indicated on the drawings or in the cable schedules all cable oversheaths shall be black.
12. Cables shall be handled, terminated and installed in accordance with the cable manufacturer's recommendations. The technical advice of the manufacturer's recommendations. The technical advice of the manufacturer's specialists shall be followed if any special conditions or unusual circumstances apply.
13. Where cable sizes are not indicated on the drawings or in the cable schedules, the contractor shall be responsible for determining the correct size of each cable. Cable sizes shall be determined on the basis of current rating and/or voltage drop and/or earth loop impedance, together within allowance for grouping with other cables and the method of installation, whichever is relevant, after taking into account the type of cable, the ambient conditions, the method of installation and the disposition of each cable relative to other cables.

14. Full details, with illustrations, of all cable supports and fixing devices shall be submitted before any orders are placed or work put in hand. All cable supports and fixing devices shall be designed to have a factor of safety of not less than 4.
15. Wherever cables pass through walls, ceilings, partitions and the like, a heavy-gauge PVC sleeve shall be provided, of internal diameter greater by at least 15 mm, but not more than 25 mm, than the diameter of the cable.
16. The length of any such sleeve shall be such that each end projects by 5 mm beyond the surface of the element through which it passes, and the ends of the sleeve shall be provided with an adequate radius to prevent chafing of the cable sheath.
17. Wherever cables pass through floors a heavy-gauge steel sleeve shall be provided, of internal diameter greater by at least 15 mm, but not more than 25 mm, than the diameter of the cable and projecting above floor level by at least 50 mm.
18. Where cables pass through walls and/or floors which form part of the building's fire compartmentation, the hole(s) through which the cables pass shall be sealed after the cables have been installed, so as to give the same standard of fire resistance as the original wall or floor. Details of the proposed sealing method shall be submitted prior to implementation.
19. Fire resistance cables shall be used as indicated in the cable schedules. Cables shall be single core or multi-core with fire resistance property 750 C° according to IEC 60331.
20. Flame retardant cables shall be used for cables laying in the plenum area and as indicated in the cable schedules. Cables shall be single core or multi-core with flame retardant cable tested accordingly to IEC 60332. Cables shall be LSHF according to IEC 60754.

2.3 CABLE INSTALLATION

A. FEEDER AND SUB-FEEDER INSTALLATIONS

1. Cabling and wiring installation shall be performed strictly in compliance with the IEE wiring regulation 16th edition.
2. Indoor distribution feeders and sub-feeders such as to distribution panel boards, motor control-gear, isolating switches etc. shall be in the form of single conductor pulled inside conduits, or raceways or multi-conductor cables clipped on cable trays, all as generally shown on the Drawings (with reference to the Schedules).
3. Where two or more cables are run in parallel, they shall be fixed on galvanized steel trays or in approved special cable supporting and protecting raceways.

4. Cables shall be fixed to the supporting structures with approved galvanized steel clamps at distances not exceeding 20 diameters. No joints or splices shall be accepted on main feeders and sub- feeders.
5. Wires and cables shall be routed in such a way that they are not exposed to excessive heat or to corrosive agents. If such a condition cannot be complied with the wires and cables shall be of a type designed for the particular condition or enclosed in the necessary protective raceway, duct, concrete etc.

B. FINAL SUB-CIRCUIT WIRING

1. Final sub-circuit work originating from light and power panelboards shall be arranged as shown on the Drawings.
2. All wiring shall comply with IEC 60502 and all conductors shall be copper pvc insulated (450/750 volt.).
3. Unless otherwise specifically indicated on the Drawings, all final sub-circuit wiring shall be run as follows:-
 - Single – core conductors PVC insulated inside conduits in areas / rooms without false ceilings.
 - Multi – core cables PVC/PVC insulated inside cable trunking in areas / rooms with false ceiling.
4. At least 150 mm of free conductor shall be left at each outlet, switch point and pull box for the making up of joints, or the connection of fixtures or devices, except where conductors are intended to loop without joints through lamp holders, receptacles and similar device boxes.

C. IDENTIFICATION OF CABLES AND WIRES

1. Except in the case where it is terminated in full view onto a clearly labelled switch, starter, distribution board or similar piece of apparatus, or onto a motor or other item of equipment the function of which is evident, each and every cable end shall be provided with an approved means of identification. In particular, this requirement shall apply to all cables terminating on the back, or in the base, of cubicle type or similar switchboard or control panel and in any other case where the function of the cable is not immediately obvious.
2. The means of identification shall be one or other of the following:-
 - (i) An engraved brass label securely fixed to the cable sealing box.
 - (ii) A stamped brass label securely tied to the cable with tinned copper binding wire.
3. Self-adhesive embossed plastic labels will not be accepted as means of identification.

4. The means of identification shall give the cable size, number of cores, and function together with the cable reference number if one has been allocated.
5. All cables run above ground shall be identified by means of engraved or stamped brass label at intervals not exceeding 30 meters. The labels shall bear details of the cable size, number of cores, function, and reference number (if any) and shall be securely attached to the cables with tinned copper binding wires.

D. TERMINATIONS OF L.V. WIRES AND CABLES

1. Terminations of wires and cables of sizes up to 16 mm², shall be tightly twisted and where possible doubled back before being clamped. Where two or more wires are looped into the same terminal these conductors shall be tightly twisted together before being inserted into the terminals.
2. Wires and cables of sizes over 16 mm² shall terminate with sweated or compression type lugs. Insulating sleeve shall be used to protect any exposed part of the conductor or sleeve projecting beyond any insulated shrouding or mounting of a live terminal.
3. Glands for the various types of multi core cables shall be purpose made and suitable for the equipment enclosure.

2.4 CABLE TESTING

1. As soon as is practicable after the completion of installation and termination of the cables specified herein, or of any usable group of such cables, the Contractor shall carry out the tests described below, together with such other tests and measurements to prove compliance with this Specification and with the requirements of the IEE Wiring Regulations 16th edition.
2. An insulation resistance test, carried out with a "Megger" insulation tester or other similar type of testing instrument, to measure the insulation resistance between each conductor and the remaining conductors and between each conductor and the metallic sheath (if any) and armouring. The voltage to be applied shall be 1000 volts.
3. The above tests shall be carried out both before and after any pressure tests and the insulation resistance shall not be less than the half mega ohms for all low voltage cables . The contractor shall submit insulation resistance figures for all cables .
4. A voltage test of 15 minutes duration shall be applied at the test voltage indicated in IEE wiring regulation 16th edition.
5. The Contractor shall submit proposals on the appropriate test voltage in respect of other types of cable.
6. Phase-rotation and phase-correspondence shall be tested to prove that the cables have been correctly connected.

PART 3 - EXECUTION

3.1 INSPECTION

1. Examine conditions under which wires, cables and connections are to be installed. Notify Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

1. Install wires, cables and connectors as indicated, in accordance with manufacturer's written instructions, requirements of applicable Standards and in accordance with recognized industry practices to ensure that installation complies with requirements and serves intended function.
2. Coordinate as necessary to properly interface installation of wires/cables with other work.
3. Pull conductors simultaneously where more than one is being installed in same raceway.
4. Use anti-seize compound for copper lug connections to bus bars.
5. Use pulling compound or lubricant, where necessary; compound used must not deteriorate conductor or insulation.
6. Use pulling means, including fish tape, cable, rope and basket weave wire/cable grips which will not damage cables or raceway.
7. Install exposed cable, parallel and perpendicular to surfaces, or exposed structural members, and follow surface contours, where possible.
8. Complete conduit or raceway installation (joints made up tightly and the entire run secured in place) before pulling wire and cable.
9. Support wires and cables at the upper end of all risers and at intermediate points.
10. Seal, between the wire and conduit with a non-hardening compound approved for the purpose, cable and wire entering a building from underground where cable exits the conduit.
11. Install cable spacers where required. Provide conduit fittings for spacing of cables at terminations, consisting of galvanized or cadmium plates, steel or malleable iron threaded conduit and fittings and inserts of non-metallic insulating material with openings adequate to accommodate cables being spaced.
12. In trunkings and large pull boxes, lace and tie off conductors in groups of 3 phases and neutral as installed in conduits to limit conductor unbalanced loading.
13. Leave all wires with sufficient slack at terminal ends and lighting fixtures for convenient connections and servicing. Stow loose ends neatly in outlet box.

14. Provide splices and taps in accessible boxes, panelboards fittings, gutters, terminal panels, etc., only. Provide materials compatible with the conductors, insulations and protective jackets on the cables and wires.
15. Tie all circuit and control wiring in cabinets, panels, pullboxes, and junction boxes.
16. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values.
17. Connect electrical power supply conductors to equipment conductors in accordance with equipment manufacturer's written instructions and wiring diagrams.
18. Prepare cables and wires, by cutting and stripping covering armor, jacket, and insulation properly to ensure uniform and neat appearance where cables and wires are terminated. Exercise care to avoid cutting through tapes which will remain on conductors. Also avoid "ringing" copper conductors while skinning wire. Cut armored jackets with tools made specifically for that purpose.
19. Do not install thermoplastic wires in computer area raised floors.

3.3 FIELD QUALITY CONTROL

1. Check for physical damage and proper connection in accordance with drawings.
2. Megger conductors phase-to-phase and phase-to-ground for continuity and insulation tests before connection to utilization devices for the main feeders, sub – feeders, branch circuits, three phase circuits...etc.
3. Perform tests prior to connecting equipment and in presence of authorized representatives.
4. Submit written reports of test results.
5. Prior to energization, test wires and cables for electrical continuity.
6. Subsequent to wire and cable hook-ups, energize circuits and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance. Replace units which cannot be satisfactorily corrected.

END OF SECTION 04

SECTION 05

MISCELLANEOUS CONTROL EQUIPMENT

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions (General requirements), apply to work of this section.
- B. Basic electrical materials and methods, section 16050 applies to work of this section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, all miscellaneous control equipment in accordance with Drawings and Specifications.

1.3 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in the manufacture of miscellaneous control equipment of the types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years. Provide miscellaneous control equipment produced by a manufacturer listed as an Acceptable Manufacturer in this section.
- B. Standards Compliance: Comply with requirements of applicable local codes, IEC 60947 pertaining to miscellaneous control equipment.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's data for miscellaneous control equipment, including sizes, types, finishes, electrical ratings and characteristics.
- B. Samples : submit samples of all control equipment.

PART 2 - PRODUCTS

2.1 RECOMMENDED MANUFACTURER

Refer to list of recommended manufacturers.

2.2 CONTACTORS AND REMOTE CONTROL RELAYS

A. GENERAL

- 1. Mechanically or magnetically held with contacts normally open or normally closed and/or combination required.

2. Rated for continuous operation with capacities and voltage at 50 Hz, as indicated on drawings or required.
3. Spring loaded contacts to maintain contact pressure in closed position, readily replaceable, self-aligning type.
4. Suitable for inductive or non-inductive loads, unless otherwise noted.
5. With arc shields and magnetic blow coils if interrupting duty exceeds 300 ampere.
6. Interrupting capability not less than six times rated full load current.
7. Operating coils voltage: 220 volts, unless otherwise noted.

B. MECHANICALLY HELD CONTACTORS

1. Single and/or dual coil operation.
2. Positive locking type without the use of latching hooks or magnets.
3. With a manual operator for hand operation giving positive indication of contactor position.
4. Control Circuit: For 3-wire operation with momentary contact open/close stations as indicated.

C. MAGNETICALLY HELD CONTACTORS

1. Spring assisted gravity open on normally open contacts and spring loaded magnetically open in normally closed contacts.
2. Control Circuit: For 2-wire operation with maintained contact open/closed stations as indicated or required.

2.3 MULTIPLE POLE RELAYS

- A. Electrically operated, mechanically held type, with 10 amperes minimum rated contacts (unless otherwise indicating or required).
- B. Open and close coils rated 220 volts or 380 volts, 50 Hz, unless otherwise indicated or required.
- C. Number of poles as indicated on drawings or schedules.

2.4 LOW VOLTAGE CONTROL POWER TRANSFORMERS

- A. Rated as required for voltage, momentary volt-ampere load, continuous volt-ampere load and suitable for the intended application.
- B. With primary and secondary over current protection with fused switches in the metal casing of the transformer (package unit).

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which miscellaneous control equipment are to be installed. Notify Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install miscellaneous control equipment and accessories as indicated in accordance with manufacturer's written instructions, requirements of applicable Standards in accordance with recognized industry practices to ensure that installation complies with requirements and serves intended function.
- B. Coordinate as necessary to interface installation of miscellaneous control equipment work with other work.
- C. Protect miscellaneous control equipment systems from dirt, moisture and construction debris subsequent to and during installation until project is accepted by Owner.
- D. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors.
- E. Mount all equipment in cabinets suitable for installation with all necessary bus bars and terminal strips. Separate low and high voltage sections with barriers.
- F. Provide all wiring, conduit and accessories including but not limited to terminal strips, rectifiers, switches, and fuses for systems to perform intended function.
- G. Provide emergency shut-down facilities at mechanical equipment rooms and other locations indicated on drawings and as required.

3.3 FIELD QUALITY CONTROL

- A. Prior to energization of installed miscellaneous control equipment, test for electrical continuity of circuitry and for possible short circuits.
- B. Electrically energize miscellaneous control equipment systems and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance. Replace equipment which cannot be satisfactorily corrected.

END OF SECTION 05

SECTION 06
MEDIUM VOLTAGE CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions (General requirements), apply to work of this section.
- B. Basic electrical materials and methods, section 16050 applies to work of this section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all medium voltage (11 KV) cables, terminations and connections, complete with all accessories in accordance with Drawings and Specifications and as required for a complete system. Cable size referenced in this Section is metric.

1.3 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in manufacture of medium voltage cables, and connections of types, sizes and ratings required, whose products have been in satisfactory use in similar service for not less than 10 years.
- B. Standards Compliance: Comply with requirements of applicable local codes, IEC 60502 pertaining to medium cables joints and terminations.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturers' data on medium voltage cables and connectors.
- B. Samples : Submit 50 cm length cable of each type and size of medium voltage cables, Manufacturer Name, insulation class and reference No. Should be indicated on the Submitted Sample.

PART 2 - PRODUCTS

2.1 RECOMMENDED MANUFACTURERS

Refer to list of recommended manufacturers.

2.2 GENERAL

- A. Provide all of the medium cables shown on the drawings.
All cables shall comply with IEC 60502 and all conductors shall be aluminium XLPE insulated armoured and P.V.C. sheathed (12/20 K.v).
- B. Conductors shall be stranded, round and compacted according to IEC 60228.

- C. The insulation of each conductor shall be colour coded and shall be maintained throughout the entire installation.
- D. For each lot of cable supply a certificate of origin issued by the manufacturer stating its origin, manufacturer, constitution and standards to which it complies with. In the absence of such documents, the Engineer reserves the right to require that tests, at the Contractor's expense, be performed by an official laboratory on samples taken from lots of cables delivered to the Site.
- E. Be responsible for any delays in the work resulting from non-compliance with the requirements mentioned above.
- F. Cable installations whether so indicated or not shall include all joints and their accessories at terminating ends earthing and bonding etc. Carried to completion.
- G. All cables shall be delivered to site with the manufacturer's seals, labels, or other proof of origin intact. Such labels and seals shall not be removed until the cable is required for use, and shall be retained for inspection.
- H. Unless otherwise specified herein or indicated on the drawings or in the cable schedules all cable oversheaths shall be black.
- I. Cables shall be handled, terminated and installed in accordance with the cable manufacturer's recommendations. The technical advice of the manufacturer's recommendations. The technical advice of the manufacturer's specialists shall be followed if any special conditions or unusual circumstances apply.
- J. Full details, with illustrations, of all cable supports and fixing devices shall be submitted before any orders are placed or work put in hand. All cable supports and fixing devices shall be designed to have a factor of safety of not less than 4.
- K. Wherever cables pass through floors a heavy-gravy-gauge UPVC sleeve shall be provided, of internal diameter greater by at least 15 mm, but not more than 25 mm, than the diameter of the cable and projecting above floor level by at least 50 mm.
- L. Where cables pass through walls and/or floors which form part of the building's fire compartmentation, the hole(s) through which the cables pass shall be sealed after the cables have been installed, so as to give the same standard of fire resistance as the original wall or floor. Details of the proposed sealing method shall be submitted prior to implementation.

2.3 MEDIUM VOLTAGE CABLES

A. GENERAL REQUIREMENTS

1. M.V. cables shall be XLPE with armour sheath, three core, 240 mm² Aluminum conductor.
2. The cables shall comply with the IEC 60228, 60230 and 60502.

B. CONSTRUCTION

1. Construction of 12/20 k.V. cables shall have three conductors of Aluminum concentric standard wires in accordance with IEC- 60288 "Nominal cross-section and composition of conductors of insulated cables".
2. Each conductor shall have an extruded screen covering of semi-conducting compound.
3. Each conductor shall have a zone resistant layer of cross- linked polyethylene (XLPE) extruded on the screened conductor.
4. The insulation shall be suitable for continuous conductor temperature of 90°C, maximum emergency conductor temperature 130°C and maximum short circuit conductor temperature 250°C.
5. Each core (insulated conductor) shall be screened by either a semi conducting, tape or layer of extruded semi conducting compound, but shall be completely free stripping.
6. Each screened core shall be shielded with a layer of copper tape.
7. Each shielded core shall have an extruded sheath of thermoplast, to prevent moisture from penetrating and provides a good corrosion protection.
8. The three cores shall be assembled together, the interstices filled with non-hygroscopic material so that the completed cable assembly is of substantial circular cross-section.
9. The inner covering wrapping the three cores together shall be of extruded corrosion resistant material. The materials used for the filler and inner covering shall be suitable for the cable operating temperature. The thickness of the inner covering shall be in accordance with IEC - 60502.
10. Identification of cables shall be carried out by embossing on the outer PVC sheath the voltage rating (class), size and number of conductors, manufacturer's name throughout the whole length of cables.
11. Identification of phases shall be carried out by using numbered insulated metal tapes (1, 2 & 3) throughout the whole core under the copper shield.

2.4 CABLE TESTING

- A. As soon as is practicable after the completion of installation and termination of the cables specified herein, or of any usable group of such cables, the Contractor shall carry out the tests, together with such other tests and measurements to prove compliance with this Specification and with the requirements of the IEE Wiring Regulations.
- B. An insulation resistance test, carried out with a "Megger" insulation tester or other similar type of testing instrument, to measure the insulation resistance

between each conductor and the remaining conductors and between each conductor and the metallic sheath (if any) and armouring.

- C. The above tests shall be carried out both before and after any pressure tests and the insulation resistance shall not be less than the figures in IEC 60230. The contractor shall submit insulation resistance figures for medium voltage cables .
- D. A voltage test of 15 minutes duration shall be applied in accordance with the in IEE wiring regulation 16th edition.
- E. Phase-rotation and phase-correspondence shall be tested to prove that the cables have been correctly connected.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which medium voltage, cables are to be installed. Notify Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install cables as indicated, in accordance with manufacturer's written instructions, requirements of applicable Standards and in accordance with recognized industry practices to ensure that installation complies with requirements and serves intended function.
- B. Coordinate as necessary to properly interface installation of cables with other works.
- C. Pull cables simultaneously where more than one is being installed in same raceway.
- D. Use pulling compound or lubricant, where necessary; compound used must not deteriorate conductor or insulation.
- E. Use pulling means, including fish tape, cable, rope and basket weave cable grips which will not damage cables or raceway.
- F. Install exposed cable, parallel and perpendicular to surfaces, or exposed structural members, and follow surface contours, where possible.
- G. Complete conduit or raceway installation (joints made up tightly and the entire run secured in place) before pulling cables.
- H. Seal, between the cable and conduit with a non-hardening compound approved for the purpose, cable entering a building from underground where cable exits the conduit.
- I. Install cable spacers as required. Provide conduit fittings for spacing of cables at terminations.

3.3 FIELD QUALITY CONTROL

- A. Check for physical damage and proper connection in accordance with drawings.
- B. Megger conductors phase-to-phase and phase-to-ground for continuity and insulation tests before connection to utilization devices.
- C. Perform tests prior to connecting equipment and in presence of authorized representatives.
- D. Submit written reports of test results.
- E. Prior to energization, test cables for electrical continuity.
- F. Subsequent to cable hook-ups, energize circuits and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance. Replace units which cannot be satisfactorily corrected.

END OF SECTION 06

SECTION 07

RACEWYAS, BOXES AND FITTINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions (General Requirements) apply to work of this section.
- B. Basic electrical materials and methods, section 16050 applies to work of this section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing completely coordinated raceway systems complete with boxes, fittings, supports, anchors, sleeves, hangers, clamps, straps, seals, flexible connections to vibrating equipment earthing and accessories, as specified and as required for a complete system. Conduit sizes referred to in the specifications and on the are nominal internal diameters.

1.3 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in manufacture of raceway systems, boxes and fittings of types and sizes required, whose products have been in satisfactory use in similar service.
- B. Standards Compliance: Comply with requirements of applicable local codes, and following Standards pertaining to raceways, boxes and fittings.
 - IEC 60614 for PVC conduits and fittings.
 - NEC 345 for IMC conduits and fittings.
 - NEC 346 for EMT conduits and fittings.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including specifications and installation instructions, for each type of raceway system and box required. Include data substantiating that materials comply with requirements.
- B. Samples: Submit 15cm length of each type of raceways with associated boxes and fittings.
- C. Shop Drawings : submit dimensioned layout drawings on architectural backgrounds of raceways, boxes and fitting including, but not limited to size of raceways, boxes and fittings elevations, type and reference no.

PART 2 - PRODUCTS

2.1 RECOMMENDED MANUFACTURERS

Refer to list of recommended manufacturers.

2.2 RACEWAYS

- A. Intermediate Metal Conduit (IMC): Rigid intermediate grade, hot dipped galvanized inside and outside, threaded, for exposed installation in electrical and mechanical plant rooms and also for fire alarm and life safety system installations minimum 20mm (inner diameter).
- B. Electrical Metallic Tubing (EMT): Thin wall steel, galvanized, threadless, for exposed installation above false ceiling (ceiling voids) minimum 20mm (inner diameter).
- C. Flexible Steel Conduit (FSC): Continuous length of specially wound interlocked, galvanized strip steel, minimum 20mm (inner diameter).
- D. Polyvinyl Chloride Conduit (PVC) heavy gauge for embedded installation in concrete slab and in walls Minimum 20mm (inner diameter).

2.3 FITTINGS AND ACCESSORIES

A. General

- 1. Accessories as required including, but not limited to, bushings, knockout closures, locknuts, mounting brackets, device box extensions, switch box supports, plaster ears, and plasterboard expandable grip fasteners, which are compatible with device boxes being utilized to fulfill installation requirements for individual wiring situation.
- 2. Earthing (grounding) Bushings: With lug suitable for the size and type of earthing (grounding) conductor to be terminated.

B. Electrical Metallic Tubing Fittings:

- 1. Steel or diecast aluminum concrete tight couplings and connectors of the gland and ring compression type.
- 2. set screw type connectors are permitted for interior dry locations only.

C. Flexible Metal Conduit Fittings:

- 1. Steel insulated throat angle wedge type.

D. Intermediate Metal Conduit Fittings

- 1. Steel or diecast aluminium, standard threaded couplings, locknuts, bushings, and elbows.
- 2. Conductive type thread compounds to insure low resistance ground continuity through conduit. Watertight couplings and connections in concrete.

3. Locknuts of the bonding type with sharp edges for digging into the metal wall of the enclosure.
 4. Bushings of the metallic insulating type, consisting of an insulating insert molded or locked into the metallic body of the fitting.
 5. Corrosion resistant metallic conduit fittings.
 6. Sealing fittings of the threaded diecast aluminium type. Where sealing fittings are used to prevent passage of water vapor, utilize the continuous drain type.
- E. Polyvinyl Chloride Conduit Fittings:** As recommended by the manufacturer to match integrity of each type of raceway system.
- F. Expansion and Deflection Couplings:**
1. Comply with approved applicable standards.
 2. Accommodate 50mm deflection, expansion and contraction in any direction as determined in the architecture layout plans.
 3. Allow 30 degree angular deflection.
 4. Include internal flexible metal braid sized to guarantee conduit ground continuity and fault currents.
 5. Watertight, seismically qualified corrosion resistant threaded and compatible with associated conduit.
 6. Jacket: Flexible, corrosion resistant, watertight, moisture and heat resistant molded rubber material with stainless steel jacket clamps.
- G. Supports:**
1. Zinc coated or equivalent.
 2. Conduit hangers, designed for the purpose and have pre-assembled closure bolt and nut and provision for receiving hanger rod.
 3. Multiple conduit (trapeze) hangers not less than 45cm x 45cm, 3mm thickness steel, cold formed, dipped clamps. Hanger rods not less than 12mm diameter steel.
 4. Anchors of types, sizes and materials designed for the purpose.

2.4 OUTLET BOXES

A. Outlet Boxes

1. PVC heavy guage for concealed work, and die – cast aluminum for exposed work; boxes of shapes and sizes as required, suitable for installation at respective location.

2. With mounting holes and with cable and conduit size knockout openings.
3. With threaded screw holes, with corrosion resistant ridged cover and grounding screws for fastening surface and device type box covers, and for equipment grounding.
4. For concealed work, utilize 8cm square or octagon outlet boxes, except as otherwise required by construction devices or wiring and as follows:
 - a. Above ceiling: 4.0cm deep.
 - b. In ceiling or slab: 8.0cm deep.
 - c. In wall for fixtures: 8cm deep.
 - d. In wall for receptacles and switches: 4.0cm deep.
 - e. With raised covers and fixture studs where required.
 - f. Back-to-back boxes type not permitted.
 - g. For installation of more than two devices in a common outlet box, utilize boxes and device rings manufactured specifically for this purpose.
 - h. Outlet box device rings used to be of sufficient depth so as to make the use of extension boxes and rings unnecessary.
5. For exposed work utilize 8cm round x 5cm deep for mounting on ceilings and on walls, except as otherwise required by construction.
6. Provide blank covers for outlet boxes without devices. Covers to match adjacent plates.

2.5 JUNCTION AND PULL BOXES

- A. Heavy guage PVC for embedded installations, galvanized sheet steel with screw-on covers for exposed installations for interior work, die – cast Aluminium with threadhubs for outdoors and damp locations.
- B. Boxes of shapes and sizes as required, suitable for installation at respective location.

2.6 FOR DUCT LINES (DUCT BANK)

- A. Install duct bank in accordance with the applicable electrical codes, as shown on the drawings, and as herein specified.
- B. Slope ducts to drain towards manholes and handholes and away from building and equipment entrances. Pitch not less than 8cm in 30m. Curved sections in duct to consist whenever feasible, of long sweep bends with a minimum radius of 7m in the horizontal and vertical directions. The use of manufactured bends

is limited to building entrances and stub-ups to equipment.

- C. For underground conduit stub-ups to equipment inside of buildings, utilize galvanized rigid steel and extend a minimum of 3m clear of foundations. For stub-ups to equipment mounted on outdoor concrete slabs, utilize galvanized rigid steel and extend a minimum of 1.5m away from edge of slab. Install insulated grounding bushings on the terminations. Couple steel conduits to the ducts with suitable adapters, and the whole encased with 8cm of concrete.
- D. Upon completion of the duct bank installation, pull a standard flexible mandrel through each duct to loosen particles of earth, sand, or foreign material left in the line. Use a mandrel not less than 30cm long, with a diameter 15mm less than the inside diameter of the duct. Subsequently pull a brush with stiff bristles through each duct to remove the loosened particles. Use a brush with the diameter the same as, or slightly larger than, the diameter of the duct.
- E. Seal the ducts and conduits at building entrances and at outdoor terminations for equipment, with a suitable non-hardening compound to prevent the entrance of moisture and gases.
- F. Duct lines to consist of single or multiple duct assemblies encased in concrete installed with top of duct bank not less than 75cm below established grade. Make ducts uniform in size and material throughout the installation, unless otherwise shown or specified.
- G. Securely support and maintain uniform spacing of the duct assembly a minimum of 8cm above bottom of trench during the concrete pour with rigid, unplasticized, polyvinyl chloride spacers. Spacer spacing not to exceed 1.5m.
- H. Provide plastic spacers to maintain the following clearances between individual ducts:
 - a. For L.C services: not less than 8cm.
 - b. For power services: not less than 15cm.
- I. Couple the ducts with proper couplings. Stagger couplings in rows and layers to ensure maximum strength and rigidity of the duct bank.
- J. Extend the concrete envelope encasing the ducts not less than 8cm beyond the outside walls of the outer ducts and conduits.
- K. Within 1.5m of building and manhole and handhole wall penetrations, install reinforcing steel bars within the top and bottom of each concrete envelope to provide protection against vertical shearing.
- L. Keep ducts clean of earth, sand, or gravel during construction, and seal with tapered plugs upon completion of each portion of the work.
- M. Where new ducts, conduits, and concrete envelopes are to be joined to existing manholes, handholes, ducts, conduits and concrete envelopes, make the joints with the proper fittings and fabricate the concrete envelopes to insure smooth durable transitions.

- N. Install reinforcing deformed structural grade steel bars, 12.7mm minimum, 18cm maximum on center, as detailed, within the top, bottom and sides of each concrete envelope to provide protection against settlement and earthquake. All duct bank terminations at manholes, to be keyed to termination wall to prevent vertical shearing.
- O. Concrete pours shall be complete; partial pours are prohibited. Where complete pour is impossible, and/or designated terminations, i.e., contract limit lines, 20mm deformed structural grade bars shall be provided at the joint 18cm on center around duct bank (minimum of 4) for keying. Reinforcing rods shall extend 1m each side of joint.
- P. Use yellow polyethylene sheeting markers in earth backfill to indicate routing of conduits and/or duct banks on all exterior underground work. Install in backfill approximately 30.5cm below finished grade. Sheeting to be full width of trenches.
- Q. Seal all unused duct openings by caulking with approximately 40mm thick oakum or approved equal formed into opening to a depth of 150mm.
- R. Provide marker flush with finished grade for all conduit and/or duct banks entering and/or leaving buildings and at all capped terminations. Provide with appropriate system identifying letter.
- S. Utilize concrete with a minimum rating of 24 Newton/mm² (3000 psi) in 25 days.

2.7 SITE MANHOLES

- A. Constructed of 32 Newton/mm² (4,000 psi), in 28 days, concrete with steel reinforcement and chimneys where indicated or required. Each manhole shall have sufficient depth to accommodate required grading of ducts, as well as maintaining minimum distance of 22cm from bottom of lowest duct centerline entering manhole to finished floor line and/or top duct to roof of manhole. Manhole shall be built on, or placed over, a 150mm layer of well tamped gravel and 50mm mud slab. Prior to installation, a 2.5 mm base membrane polyurethane membrane is to be installed (See subsequent Paragraph B). Minimum overall sizes and details as indicated on the drawings.
- B. All manholes shall be watertight and furnished with sump pits. Floor shall be graded in order to accommodate draining to pit. Outside surfaces of manhole and pull boxes shall be coated with an approved polyurethane water-proofing coating of 1.8 mm minimum thickness (all sides and roof). Care shall be taken to assure bonding of side coating with base membrane.
- C. Bolted and Gasketed Manhole Frames and Covers: Cast iron of indicated size. Set frame and cover to final grade as indicated or required. Fully coordinate with the civil and landscape details.
- D. Duct envelopes and conduit shall enter manholes and pull boxes at right angles to box wall.
- E. Cables shall be well supported on walls by cable racks, attached to the wall with

hot dipped galvanized machine bolts and stainless steel inserts, and equipped with adjustable rack arms and insulators. At least two cable racks shall be installed and/or as scheduled on drawings, with not less than two spare rack arms on each cable rack. Insulators not required on spare rack arms.

- F. Bolt or studs imbedded in concrete for cable rack mounting are not acceptable.
- G. Install pulling eye irons imbedded in walls opposite each duct entrance plus the floor, and securely fastened to the manhole reinforcing rods before concrete is poured.
- H. All hardware used in the manhole shall be hot-dipped galvanized.
- I. In manholes and pullboxes, bond to "Z" bar ground bus with 35mm² bare copper ground all metal non-current carrying parts, e.g., cable racks, frames, bushings, etc.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which raceways, boxes, accessories, and fittings are to be installed and substrate which will support raceways. Notify Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General

1. Install raceways, boxes, accessories, and fittings as required, in accordance with manufacturers' written installation instructions, requirements of applicable standards, and in accordance with recognized industry practices to ensure that installation complies with requirements and serves intended function.
2. Coordinate as necessary to interface installation of electrical raceways, boxes, and components with other work. Run raceways concealed, except as noted.
3. Mechanically fasten together metal conduits, enclosures, and raceways for conductors to form continuous electrical conductor. Connect to electrical boxes, fittings and cabinets to provide electrical continuity and firm mechanical assembly. Maintain grounding continuity of interrupted metallic raceways with ground conductor.
4. Avoid use of dissimilar metals throughout system to eliminate possibility of electrolysis. Where dissimilar metals are in contact, coat surfaces with corrosion inhibiting compound before assembling.
5. Support raceways by means of ceiling trapeze, strap hangers, wall brackets with back spacer, structural steel angles or channels. Support riser raceways at each floor. Secure raceways to supports with pipe

straps or U-bolts. Space supports as per applicable electrical code and per manufacturer's recommendations, unless otherwise indicated.

6. Mount supports to structure with toggle bolts on hollow masonry, expansion shields or inserts on concrete and brick, machine screws on metal, wood screws on wood. Nails, rawl plugs, wood, and/or plastic plugs are not permitted.
7. Keep raceways clear of motor foundations and boilers. Also, do not obstruct headroom, doorways, or walkways, with raceway.
8. Do not install conduit in terrazzo floors.
9. Install miscellaneous fittings such as reducers, chase nipples, 3-piece unions, split couplings, and plugs that have been specifically designed and manufactured for their particular application.
10. Use roughing-in dimensions of electrically operated equipment furnished by equipment supplier. Set conduit and boxes for connection to equipment only after receiving dimensioned drawings from equipment installer and after checking location with other trades.
11. Test conduits required to be installed, but left empty, with ball mandrel. Clear any conduit which rejects ball mandrel.
12. Provide long radius bends for empty raceway systems where required to satisfy the system cabling requirements.
13. Install complete raceway runs before pulling in wire or cable. Install raceways so that required conductors may be drawn in without injury or excessive strain to raceway or cable. Where raceway size is not indicated, follow applicable code.
14. Keep end of raceways plugged or capped during construction.
15. For empty raceways over 3m long, provide fish or pull wire. For 4.0cm and larger pull wire to consist of steel core nylon rope and terminal ball.
16. Remove damaged or deformed raceways.
17. Do not support branch circuit conduits by the suspended ceiling or its supporting members, lighting fixtures, mechanical piping, or air conditioning ducts.
18. Conduits are not to cross pipe shafts or ventilating duct openings. Avoid present and future openings in floor, wall or ceiling construction, when so indicated on drawings.
19. Keep conduits a minimum distance of 45cm from parallel runs of flues or boiler breaching and 15cm from hot water pipes or other sources of heat. Wherever possible, install horizontal raceway runs above water and steam piping. Provide thermal insulation where these separations cannot be maintained.

20. Support riser conduit twice at each floor level with clamp hangers.
21. Use of running threads at conduit joints and terminations is prohibited. Where required, use 3-piece union or split coupling.
22. Provide knockout closures to cap unused knockout holes where blanks have been removed.
23. Install electrical boxes in those locations which ensure ready accessibility to enclosed electrical wiring.
24. Do not install boxes back-to-back in walls. Provide not less than 150 mm separation.
25. Do not install aluminum products in concrete. Plug and seal conduit interconnections.
26. Position recessed outlet boxes accurately to allow for surface finish thickness.
27. Fasten electrical boxes firmly and rigidly to substrates or structural surfaces to which attached or solidly embed electrical boxes in concrete or masonry.
Subsequent to installation of boxes, protect boxes from construction debris and damage.
28. Set boxes square and true with the building finish. Secure boxes to the building structure and adequately support all boxes during construction to prevent movement.
29. Verify outlet locations in finished spaces with Architectural Drawings or Interior Design drawings, details and finishes. Take caution in locating outlet to allow for overhead pipes, ducts, and variations in arrangement, thickness in finish, window trim and other Architectural Construction Details.
30. Correct any inaccuracy in locating outlets without additional expense to the Owner. Refer to Architect any condition that would place an outlet box in an unsuitable location, such as a molding, break glass in wall finish, ...etc.
31. Mount outlet boxes for similar equipment at uniform height within same or similar areas. Where mounting height or location of outlets is not shown or specified, mount outlet as best suited for equipment connected thereto, or as directed.
32. Provide barriers between switches connected to different phases.
33. Except where special outlets are required, provide 10cm square wall outlets with single gang raised cover and bushed plate for signaling systems.

34. In cold rooms, walk-in refrigeration boxes, etc., weatherproof raceway installations and use sealing fittings and compounds as entries.
 35. For conduit (or cable trays) runs exposed inside the building, mark (stencil 3 M on centers, including in hung ceiling, with the notation, "Danger, Volts," indicating the actual voltage (i.e. "Danger 22,000 Volts," "Danger 380 Volts")....etc.
 36. For conduits and direct burial cable entering the building and for the manholes preceding the conduits entry to the building, perform the following:
 - a. Plug all empty raceways.
 - b. Enter through floor or wall entrance fittings. For the entrance fittings utilize a gland assembly cable of providing a seal around the cable.
 37. Work with extreme care near existing ducts, conduits, cables and other utilities to avoid damaging them.
 38. Provide weather-tight outlets for interior and exterior locations exposed to weather or moisture.
 39. Set floor boxes level and flush with finish flooring material. Coordinate trim with type of finish, i.e., tile, carpet, etc.
- B. For all vibrating equipment adjacent or above acoustically treated areas, i.e., meeting rooms, class rooms, etc., provide the following:
1. Flexible conduit at the entries, exits, and outlets.
 2. Seal in fittings with compound at the entries and exits.
 3. Supports of rubber-in-shear ceiling hangers.
 4. Expansion fittings at isolating slab joints.
 5. Rubber gasketed recessed outlets.
 6. Back plaster recessed outlets.
 7. Free-standing equipment with vibration isolators.
- C. Intermediate Metal Conduit (IMC)
1. Use intermediate metal conduit for exposed installations in electrical and mechanical plant rooms and tunnel.
 2. For fire alarm system network.
- D. Electric Metallic Tubing (EMT)
1. Use electrical metallic tubing for branch circuits only, in dry locations

(hung ceilings, hollow block walls and furred spaces) and for communication system where in accordance with all applicable codes.

2. EMT is not permitted to be used in mechanical equipment spaces and where subject to moisture, dampness, i.e. plenums, condensate spillage, etc.

E. Flexible Steel Conduit (FSC)

1. Use flexible steel conduit with an internal earth connection for short connections where rigid conduit or tubing is impracticable and for final connections to vibrating equipment.
2. Provide a minimum length of 50cm with slack. Connect the earth conductor to the enclosure or raceway at each end.

F. Polyvinyl Chloride Conduit (PVC)

1. Use in or below slabs for service entrance conductors for lighting system and communication service and only as otherwise indicated. Provide separate earthing wire.
2. Cut ends square, ream smooth, wipe clean, apply approved solvent cement and quarter turn as drawing up tight in accordance with recommendations of manufacturer.
3. Maintain a one meter minimum clearance of PVC conduits from hot water and steam lines.
4. Where located under building, concrete encase conduit for all runs above 50mm.
5. Conduit, fittings and accessories shall be of the same manufacture to provide a consistent system with compatible appearance. The use of alternative designs and different manufacturer's products will not be permitted.
6. All conduit joints shall be made in accordance with the manufacture's installation recommendations using a solvent adhesive recommended by the maker of the conduit. All such joints shall be watertight. The same conditions shall apply to joints between conduit, fittings and accessories. The dipping of conduit or fittings into solvent adhesives is expressly forbidden. Before joints are made, conduit ends shall be cut square and all burrs and sharp edges shall be removed. Care should be taken to remove all damp, grease, cement dust and oil from all faces of conduits and accessories prior to jointing. Conduits shall be entered fully into box spouts and butted into couplers, other than expansion couplers, for jointing purposes.
7. Screwed PVC conduit shall not be used unless specifically called for on the drawings or when the PVC conduit is to be connected to metal equipment, conduit and fittings with screwed entries. Where such

entries are not available, non-screwed male bushes and couplers shall be used.

8. Where conduit crosses building expansion joints or where there are changes of temperature in excess of 25 °C, flexibility of the conduit to cope with the associated movement shall be achieved by a method approved by the manufacturer of the conduit.
 9. All bends shall be made using the correct size spring. Conduit sizes of 25 mm and below may be set cold but all larger sizes shall be set hot. A pipe vice shall not be used during this or any other operation. The radius of any conduit bend shall not be less than 4 times the outside diameter of the conduit. Naked flames shall not be used directly to heat conduit for bending purposes. The use of conduit bends having fractures and conduits with any wrinkles on formed bends is not permitted.
 10. Concealed conduit and accessories shall be securely fixed before any operations involving casting, concrete pouring, screed laying and plastering. Fixing shall be by means purpose made clips which shall not cause deformation of the conduit. Fixings shall be used at regular intervals not exceeding 1.5 meters and the distance of clips on each side of bends or accessories shall not exceed 150 mm.
 11. A protective conductor of not less than 2.5 mm² with green and yellow insulation shall be installed throughout, sufficiently long to allow looping in and of fittings and accessories. Where expansion couplers are used allowance shall be made in the length of the protective conductor to accommodate any expansion.
 12. Where luminaires are to be connected to a ceiling conduit system, metal conduit boxes shall be used. Luminaires can not be hung from the PVC conduit system and full details of the means of support shall be shown on the contractor working, Co-ordination and Builders Work Drawings.
 13. Where a number of conduits converge, large adaptable PVC boxes shall be employed to avoid the conduits crossing. Conduits shall be connected to the boxes by means of male bushes and couplers.
- G. Provide expansion-deflection fittings at expansion joints and on length of runs in accordance with manufacturer's recommendations. Utilize expansion-deflection fittings of size as required complete with bonding jumper.
- H. For Wet, Damp, or Moist Locations
1. Provide sealing fittings to prevent passage of water vapor, where conduits pass from warm to cold locations, such as refrigerated spaces, air conditioned spaces, or similar spaces.

3.0 FIELD QUALITY CONTROL

- A. Upon completion of installation of raceways, perform continuity tests by testing the resistance of all feeder conduits from the service to the point of their final

distribution. Limit the maximum resistance 25 ohms. When possib, field-correct malfunctioning equipment, then retest to demonstrate compliance. Replace equipment which cannot be satisfactorily corrected, at no additional cost to the Owner.

END OF SECTION 07

SECTION 08

CABLE TRAYS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions (General requirements), apply to work of this section.
- B. Basic electrical materials and methods, section 16050 applies to work of this section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, all cable trays and cable trunkings in accordance with Drawings and Specifications.

1.3 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in the manufacture of cable trays and cable trunkings of the types and capacities required, whose products have been in satisfactory use in similar service for not less than 10 years.
- B. Standards Compliance: Comply with requirements of applicable local codes, IEC 61537 pertaining to cable trays and trunkings.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's data for cable trays and trunking.
- B. Samples:- Submit 50 cm length of each size of cable tray and trunking complete with its accessories and fittings.
- C. Shop Drawings: Submit dimensioned layout drawings on architectural backgrounds of cable trays and trunking including, but not limited to, offsets and connections. Show accurately scaled cable trays with locations of supports and fittings, including fire stops and weather seals. Indicate relationship of cable trays to other associated equipment indicate arrangement of cables on cable trays complete with sections and elevations.
- D. Submit a detailed calculations of capacity of cables installed inside the trunking assuring a maximum 50% occupancy.

PART 2 - PRODUCTS

2.1 RECOMMENDED MANUFACTURER

Refer to list of recommended manufacturers.

2.2 CABLE TRAYS

A. GENERAL

1. Cable trays shall be made of hot dip. Galvanized steel after fabrication.
2. All trays and system components as defined by and in conformance with approved Standards of latest applicable revisions.
3. Fittings such as elbows, tees, crosses, etc., with a tangent, or straight section beyond the curvature to accept one type of universal splice plate to simplify field erections.
4. Usable Minimum Clear Loading Depth: 8cm straight Sections: 3 meters in length.
5. All Cable trays shall be covered with plain cover.
6. Cable trays shall be perforated and manufactured from hot dip mild steel and galvanized after fabrication.
7. Minimum thickness of cable trays shall be 1.5mm for cable tray width up to 30cm and 2mm for larger size.
8. Cable trays shall be manufactured with plain return flanges
9. Adequate supports shall be provided to prevent stress on cables where they enter or leave the tray. Where cable trays extend transversely through partitions and walls additional protection in the form of fire-proof non-combustible barriers shall be provided.
10. All cables shall be fastened securely by purpose made straps or saddles to the cable trays.
11. Cable trays shall be connected by means of flexible tinned straps to the nearest bare earthing conductors and at maximum of 30 meters spacing.
12. Cable trays must be specially reinforced to have high load bearing capabilities across wide spans, maximum deflection should not exceed 0.5% in the longest span. Also it shall be mechanically designed to give high torsional rigidity and good resistance against lateral loading.
13. Where the supported cables run in either a vertical or horizontal direction, manufactured bends or sets shall be provided in order that a continuous cable tray be provided throughout the length or run.

14. Bends in either vertical or horizontal directions should be dimensioned such that cables may not be curved less than 15 times its diameter.
15. Perforate-type cable tray shall be used above the suspended ceiling. It shall be manufactured from mild steel 2 mm thick, finished hot-dip galvanized with a 20 mm return flange on both edges. Edge height 80 mm.
16. Ladder-type cable tray shall be used to support heavy cabling in electrical and mechanical plant rooms or as directed by the Engineer. The tray shall be designed ladder-like, offering free circulation of air around cable and minimum moisture and dust-gathering surfaces. Rungs shall be welded to the ladder profiles. Rung width shall not be less than 30mm, and center distance between rungs shall not exceed 250 mm.
17. Cables are to be prevented from falling down the ladder system by 50 mm height edges along the whole length of the ladder.
18. All components and accessories shall be hot-dip galvanized steel after manufacture to give resistance to corrosion.
19. Cable tray width shall be chosen by the contractor according to the number and diameter of cables laid on the tray. Main feeders shall be laid such that their outer radius are spaced a distance equal to the diameter of the largest cable.
20. Same typical details of trays, ladder and perforated type are shown in the drawings.

B. SAFETY FACTOR

1. Cable Tray at 3.0 meters Span: Capable of sustaining a working (allowable) load of 82kg per linear 30cm with a safety factor of 2, when tested as a simple beam and in accordance with approved load test method; test specimen to be a single section of cable tray.
2. In addition to and concurrent with the above working load, a 90kg concentrated load applied at mid span to result in no permanent deformation of the tray.
3. Design to be such that all like parts are interchangeable and that trays may be readily assembled and joined without the use of special tools.

C. Fittings: at least the same thickness and cross sectional area of side members and (rungs, bottom) as straight sections.

D. Connectors: High pressure rigid plate type connected by ribbed-neck or square-neck plated steel bolts and free-spinning lock type nuts not requiring a washer; ribbed-neck or square-neck portion of bolt to grip the tray side member and connector plate metal to prevent bolt from rotating during tightening of nut.

E. Where necessary, provide expansion guides and connectors per manufacturer's thermal contraction and expansion table; install fixed hold down clamps approximately midway between expansion connectors; install expansion guides at all other support locations to allow thermally induced movement of the tray.

F. Resistance of the connection between adjacent sections of cable trays: not more than 0.0003 ohms; use bonding jumpers of suitable ampacity at all expansion connections and at all adjustable points.

G. LADDER TYPE TRAY SECTIONS

1. Construct with rungs (transverse members) at least 2.5cm wide, spaced 30cm on centers.
2. Bearing Surface of Transverse Members: Minimum of 2.0 cm.
3. Rungs (transverse members) assembled to the side rails by welding to insure integrity of fault ground path for the life of the system and maximum structural capability; non-welded joining of rungs to side rails are not acceptable.

2.3 CABLE TRUNKING

A. GENERAL

1. Lengths of trunking shall be efficiently bonded to each other using strip copper links not less than 12 mm wide x 1.5 mm thick and fixed with brass nuts, bolts and gasketed serrated washers.
2. Lids shall be lipped and fixed at intervals not exceeding 1 meter by means of quick release can fasteners. Steel screws and fasteners shall be protected against corrosion by a finish at least equivalent to zinc coating.
3. Metal partitions in trunking shall be a minimum thickness of 1.2 mm and the finish shall be of the same standard as the trunking. The method of fixing partitions to the trunking shall not cause long term corrosion or electrolytic action and shall be such that the partitions cannot be inadvertently displaced.
4. Connectors shall span the complete internal surface of the trunking and shall be designed so that the trunking sections mate with butting joints.
5. Vertical trunking shall be supplied with a cable support unit with insulated pins at intervals not exceeding 3 meters.
6. Horizontal trunking sizes exceeding 100 mm x 50 mm shall be supplied with cable separators with insulated pins at intervals not exceeding 2 meters.

7. Trunking shall consist of base, snap-on covers, coupling end plates, wall flanges, panel to trunking rubber grommet, elbows, tees, adaptor plates and all necessary hangers supports and accessories.
 8. Trunking shall be constructed of hot-dip galvanized steel after fabrication with thickness 1.5 mm for 100 x100 mm 2mm for layer size all steel units shall be protected inside and outside with a corrosion resistant finish such as zinc or cadmium, with a top coat of enamel.
 9. All trunkings parts shall be mechanically and electrically coupled while protecting wires from abrasion.
- B. Where any cutting or damage is caused during erection, the finish shall be made good. All burrs and rough edges shall be removed. Where any corrosion has occurred it shall be removed and the area treated with a rust-proofing agent. After this it shall be treated by the application of either a zinc rich epoxy primer or equal alternative followed by a coat of color matching paint.
 - C. Any fixing used for securing or fitting shall not cause any long term corrosion or electrolytic action - black japanned fixing screws shall not be used. Where brackets are used they shall be constructed of mild steel angle or channel iron finished to the same standard as the trunking.
 - D. Connections to conduit, multiple box, switchgear and distribution boards shall be made with flanged units.
 - E. Where trunking crosses settlement and expansion joints a trunking joints shall be made. The connector at this point shall be made with slotted fixing holes to permit a movement of 10 mm in both the horizontal and vertical planes. The earth continuity links across such joints shall be of braided copper tape not less than 15 mm wide x 2 mm thick having a resistance from fixing to fixing equal to or less than the links used for the standard trunking joints.
 - F. The braid shall be long enough to allow for the maximum movement of the trunking. The braid ends shall be folded, and sweated soiled.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which cable trays and trunkings are to be installed. Notify the consultant in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install cable trays and trunkings and accessories as indicated in accordance with the requirements of applicable standards and in accordance with recognized industry practices to ensure that installation complies with requirements and serves intended function.

- B. Coordinate as necessary to interface installation of cable trays and trunkings work with other work.
- C. Install integral fire stops where cable trays and trunkings penetrates fire-rated walls and floors. Seal between cable trays and trunkings and opening and around opening with fire-rated sealant not less than wall, or floor, fire ratings.
- D. At floor openings provide concrete curb, 10cm wide and 10cm high, around cable trays and trunkings and seal with non-combustible material.
- E. Provide electrical bonding and equipment earthing connections for cable trays and trunkings . Tighten connections to comply with tightening torques specified by manufacturers to assure permanent and effective connections and grounds.
- F. Anchor mounting hardware firmly to walls, floors, or ceilings, to ensure enclosures are permanently and mechanically secured. Provide all hardware and accessories for proper mounting.
- G. Route cable trays and trunkings as required and make final field measurements before ordering cable tray.
- H. Where there is insufficient elevation or lateral change in direction to accommodate fittings directly connected, adjustable vertical connectors or adjustable horizontal connectors with straight section in between may be used. Avoid slopes that would cause cable to bend on smaller radii; than that allowed by cable manufacturer.
- I. Provide hangers, rods, straps, special brackets, and other means of supporting cable tray and trunkings as required.
- J. Cables shall not occupy more than 40% of the trunking cross sectional area.

3.3 FIELD QUALITY CONTROL

- A. Prior to installing cables in cable trays and trunkings, test for electrical continuity of bonding, and earthing connections, and to demonstrate compliance with earthing requirements.
- B. Electrically energize cable tray and trunkings systems and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance. Replace equipment which cannot be satisfactorily corrected.

END OF SECTION 08

SECTION 09
WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions (General requirements), apply to work of this section.
- B. Basic electrical materials and methods, section 16050 applies to work of this section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, all wiring devices in accordance with drawings and specifications.

1.3 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in manufacture of electrical wiring devices, of types, sizes, and ratings required, whose products have been in satisfactory use in similar service for not less than 10 years.
- B. Standards Compliance: Comply with requirements of applicable local codes, IEC 60669-1 and IEC 60884-1 pertaining to wiring devices.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's data on wiring devices.
- B. Samples : Submit samples of all wiring devices included in the contract.

PART 2 - PRODUCTS

2.1 RECOMMENDED MANUFACTURER

Refer to list of recommended manufacturers.

2.2 GENERAL

- A. Each type of wiring devices where applicable shall be of the same manufacture and where necessary of the same maker's catalogue number or description to provide consistent appearance and finish.
- B. Flush mounting wiring devices shall be fitted into purpose made back boxes only. All wiring devices shall be flush mounted.

- C. All boxes or sections of boxes for use with wiring devices must incorporate a suitably marked earth terminal. Accessory plates shall be secured to boxes by not less than two fixing screws. Where these screws do not provide adequate earth continuity to metal plates or plates including parts to be earthed then a bonding connection shall be provided from the earth terminal to the plate or part. The bonding shall be protected with a green/yellow insulated sleeve. The above requirement shall not apply to the earth socket on a socket outlet when directly connected to a protective conductor.
- D. Where more than one phase of a supply exists in a multi gang box the following requirements shall apply :
 - A clearly visible label showing the maximum voltage present shall be arranged as a warning notice before access can be gained to live parts.
 - Wiring and accessories connected to each phase shall be separated from each other by fixed screens or barriers.

2.3 SWITCHES & PUSHBUTTONS

- A. All switches for lighting circuits shall comply with IEC 60669-1 and shall be quick make and break for use on a.c. supplies. Switches shall be single pole and rated not less than 10 A, 220 V for use only on a.c. systems, including fluorescent or inductive loads.
- B. Switches shall be one-way or two-way or intermediate or push button as indicated on the drawings.
- C. Switches for lighting shall be of the insulated cover plate switch type with rocker operation, and in single or multi gang formation where installed in groups.
- D. In damp or outside positions, switches shall be IP54, single pole. The switch enclosure shall be weatherproof.
- E. Push buttons single units or forming part of a multi gang unit shall be rated at 10 A, 220 V. The pushbutton switch shall be single/double-pole and arranged for push to make/ to break the contacts as applicable for the application.
- F. All push buttons shall be illuminated type.

2.4 SOCKETS

- A. Socket shall be German standard 10/16A DIN (2P + E) with side earthing – contact of SCHUKO type – shuttered contact tubes.
- B. Sockets shall be of insulated cover plate in single or multi gang formation.
- C. Industrial type switched sockets shall be used in Electrical / Mechanical plant rooms, workshops etc. and shall be of all rigid metal construction for surface mounting.

- D. Three phase sockets shall be 3 poles + neutral + earth 16 Amp. Unless other wise indicated made of rigid metal construction
- E. Industrial & special type sockets shall be supplied complete with plugs.

2.5 CEILING OUTLET (LIGHTING OUTLETS)

- A. Ceiling outlet shall be considered as lighting outlet and shall be designed for the safe and efficient permanent connection of cables to a wiring system to lighting fixtures.
- B. Ceiling outlet shall consist of a base and cover moulded in white non-tracking insulating material.
- C. The cover shall either screw on to the base or be held on the base by not less than two screws. No connections or terminations shall be incorporated into the cover but it may include an outgoing flexible cable clamp.
- D. The base shall include terminals for incoming cable and outgoing flexible connections with a separate terminal unit for the earth connection.
- E. The complete ceiling outlet and its attachment to the ceiling shall be designed to support safely either the maximum weight suspended by a flexible cord from the ceiling outlet in accordance with IEE wiring regulations, or a luminaries directly attached to the ceiling outlet and having a weight up to a maximum of 25 Kg complete including shades and lamps.
- F. Ceiling outlet shall incorporate means for avoiding any mechanical load or strain from flexible pendant cables being transmitted to the terminals.

2.6 CORD OUTLETS

- A. Outlet plates for cables or flexible cords shall be similar to switch plates and complete with not less than two fixing screws. Terminals shall be provided to accommodate incoming wiring and outgoing cables or flexible cord. The unit shall be unfused and shall incorporate an outgoing cable clamp or cord grip. The cover plate shall have a smooth aperture for the cable/flexible exit.

2.7 FLOOR BOXES

- A. Material: Galvanized steal with a gray polyester corrosion-resistant finish with 2.5 mm² earthing pigtail prewired to the ground screw, with knock outs for conduit entrance and suitable to accept conduit and devices as indicated.
- B. Covers: Brass or aluminum or galvanized steal as selected by the Engineer, and suitable for indicated devices and mounting.
- C. Flanges: brass or aluminum or clear polycarbonate) as selected by the Engineer, and suitable for floor box.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which wiring devices are to be installed. Notify Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install wiring devices as indicated, in compliance with manufacturer's written instructions, requirements of applicable standards, and in accordance with recognized industry practices to ensure that installation complies with requirements and serves intended function.
- B. Coordinate as necessary to interface installation of wiring devices with other work.
- C. Install wiring devices only in electrical boxes which are clean, free from excess building materials, dirt, and debris.
- D. Install wiring devices after wiring work is completed and tested.
- E. The wall (face) – plate shape, material and colour should be per ID/Arch. Consultant approval. Install wall-plates after painting work is completed.
- F. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for wiring devices.
- G. Protection of Wall-plates and Sockets upon installation of wall-plates and sockets advise Contractor regarding proper and cautious use of convenience outlets. Prior to Owner accepting project, replace those items which have been damaged, including those burned and scored by faulty plugs.
- H. Provide equipment earthing connections for wiring devices, unless otherwise indicated.
- I. Verify exact locations of switches and receptacles with architectural and interior design drawings.
- J. Install switches indicated on plans for the various rooms directly adjacent to the entrance door and as shown on the approved shop drawings.
- K. Check the architectural drawings for the door swings and locate all switches on the lock side of the openings. Verify in field prior to switch outlet installation.
- L. Coordinate all final mounting heights with Architect's elevations and details prior to installation. Where heights are different than those indicated or specified, the architectural heights take precedence.

- M. Where two or more switches control more than one 220 volt branch circuit, barrier boxes to prevent 380 volts occurring in any one box.
- N. Where more than one wiring device is mounted in the same location, gang mount such devices under a common face plate.
- O. Vertically align devices shown above each other on the drawings on a common centerline unless shown otherwise.
- P. Where an outlet is indicated as serving a specific piece of equipment, locate outlet as required by equipment or layout roughing drawings. Work from approved equipment and roughing shop drawings to locate outlets.
- Q. Fully coordinate switched mounted in architectural frames, posts and mullions with all trades involved. Submit method of wiring and type and style switch to Architect for approval.

3.3 FIELD QUALITY CONTROL

- A. Upon completion of installation of wiring devices, prior to energizing circuitry, test wiring devices for electrical continuity. Ensure proper polarity of connections is maintained. Subsequent to energization, test wiring devices to demonstrate compliance with requirements.

END OF SECTION 09

SECTION 10

STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Special Conditions, apply to work of this section.
- B. General Provisions for Electrical Work, Section 16050, applies to work of this section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services and tests necessary to complete, make ready and set to work for operation by the Owner, Uninterruptible Power Systems, in accordance with Drawings and Specifications.

1.3 QUALITY ASSURANCE

- A. Acceptable manufacturer's: Firms regularly engaged in the manufacture of UPS Systems, of types, ratings and capacities required, whose products have been in satisfactory use in similar service for not less than 10 years as approved by the Engineer.
- B. Standard Compliance: Comply with requirements of applicable local codes and IEC 60146 standard .
- C. Service: Manufacturer must have a factory warehouse at which spare parts are stocked and where a field service engineer who is a permanent, full-time employee of the manufacturer resides nearby and is a qualified, factory trained individual whose primary duty is field service resides.
- D. Factory Testing: Before shipment, manufacturer to fully and completely test the system to assure compliance with the specification including operational discharge and recharge tests on at least a one-minute battery plant to assure guaranteed rated performance.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's data, wiring diagrams and installation instructions for UPS System.
- B. Shop Drawings: Submit dimensional layout on architectural background drawings.

1.5 EQUIPMENT WARRANTY

- A. Guarantee equipment furnished under these specifications against defective parts and workmanship under terms of the manufacturer's standard

warranties for a period of one year from date of issuance of C. of P. Provide a separate line item for labor and travel time for necessary repairs at the job site at no additional cost to the Owner.

PART 2 - PRODUCTS

2.1 RECOMMENDED MANUFACTURER

Refer to list of recommended manufacturers.

2.2 GENERAL

- A. On-line active Uninterruptible Power Supply (UPS) system shall be provided, where indicated on drawings to supply clean, regulated single-phase and three phases power for designated electrical and electronic equipment even when the incoming utility power is interrupted. The system shall consist of a rectifier/charger, inverter, static bypass switches plus external by-pass switches and sealed, low maintenance battery plant
- B. The battery plant to be sized for 15 minutes back-up time.

2.3 OPERATION

- A. UPS unit shall be configured as a true on-line system whereby the inverter section of the UPS is the main source of AC power to the critical load and the bypass AC source is utilized as the standby source in case of an extreme overload or inverter failure. Transfer to the AC source shall be automatic and without interruption.

1. Operational Modes

- a) Normal: AC power is supplied to the rectifier/charger. The rectifier/charger shall convert the AC power supply into DC and shall power the inverter as well as maintain a float charge on the battery plant.
- b) Power Failure: The inverter shall draw DC power from the battery plant. No switching or transfer shall occur. The AC output of the system shall remain constant, regulated and transient free. Should the power failure exceed the reserve time of the provided battery plant, the UPS shall electronically shut down, protecting the battery plant from irreversible damage.
- c) Return of A/C power supply (before UPS shutdown): Should the utility power return before the UPS has shut down due to low battery voltage, the rectifier/charger shall resume powering the inverter as well as recharging the battery plant.

Return of A/C power supply (after UPS shutdown): Should the power return after the UPS has performed a low battery voltage shutdown, the rectifier/charger shall restart and immediately begin recharging the battery plant. The inverter shall then perform a "self test", automatically restart and resume powering the critical load. This shall be an automatic function and require no manual operations.

- d) Bypass (internal): A continuously-rated static switch shall be supplied as an integral component of the UPS system and shall provide an uninterrupted transfer to the bypass power supply under the following two conditions:
 - 1) An overload or a short circuit in the critical load the UPS is supplying. When the short circuit or the power demand has returned to normal, the static switch shall automatically, and without interruption, return the critical load to the inverter source.
 - 2) Should a component in the inverter section fail, in any of the two UPS units the UPS shall transfer the load, without interruption, to the second unit. Re-transfer shall not occur until the failed component has been located and replaced.

2.4 RATINGS

Each UPS shall have, as a minimum the following specifications and ratings:

A. Output

1. Power Ratings: as indicated in the drawings and schedules.
2. Voltage: 380 volt, three phase or
220 volts, single phase,
plus earth, 50
Hertz
3. Inverter Overload Current:
 - a) At 0.8 pf lagging load: 110% indefinitely
125% for 10 minutes
150% for 60 seconds
 - b) At unity pf (full rated kW) with delayed transfer 120% for 15 seconds
125% for 8 seconds
 - c) Load Power Factor: Any
 - d) Voltage Regulation (static): +/- 1% over full input ,
power factor, temperature
and load range.
 - e) Voltage Regulation: The maximum voltage deviation
for 8 ms duration
(Dynamic response) for
transient
application or removal of

100% rated load in less
than +/- 2%.

4. Frequency:
 - a) Stability: +/- 01% free-running
 - b) Slew Rate: 1 Hz/second
 - c) Synchronization Window: 48.8 Hz to 51.2 Hz
(+/-2% of nominal)
 - d) Load Crest Factor: 3.1
 - e) Harmonic Distortion: 2% THD for all factors of
line and load
5. Output Short Circuit Protection: The UPS shall be
capable of withstanding a
direct short circuit at the
output terminals without
damage to any power
components.

B. Input

1. Voltage: 220 V AC, single phase,
or 380 V AC three phase
plus earth, 50 Hertz
(refer to design drawings).
2. Protection: Thermal Magnetic: Circuit
Breaker
3. Bypass Input: 220 V AC, 1 phase, 3 wire,
or 380 V AC, 3 phase ,
5 wire, 50 Hz, and protected
by a thermal magnetic circuit
breaker.
4. Range: +/- 15%/-20% (without battery
discharge)
5. Frequency: 47 to 63 Hz (without battery
discharge)
6. Inrush Current Walk-in: 5 seconds to full load
7. System Efficiency (AC-AC) at half/full rated load:
81%/85%

C. Environmental

1. Ambient Operating

Temperature Range:	The UPS shall be capable of continuous operation at full rated capacity when subjected to an ambient operating temperature of 0 to 40 C ⁰ .
2. Storage Temperature Range:	-20 to 60 C ⁰ .
3. System Battery:	25 C ⁰ . recommended
4. Relative Humidity:	0% to 95% non- condensing.
5. Audible Noise:	50 dBA maximum at 1.5 feet.
6. Cooling:	Cooling fans, rate controlled by % of load and internal cabinet temperature.

2.5 SYSTEM COMPONENTS

A. Rectifier/Charger:

1. Type:	Full wave Phase-Controlled type using insulated gate bipolar transistor (IGBT) in both the positive and negative legs to eliminate even order harmonics.
2. Protection:	Thermal Magnetic Circuit Breaker.
3. Magnetizing Inrush Current:	Limited to 6 times the nominal current for a duration not to exceed 20 milliseconds.
4. Rectifier Efficiency:	96%
5. Ripple Current:	Less than 3%
6. Inverter	
a) Type:	20KHZ Pulse-Width-Modulated (PWM), IGBT type (insulated gate bipolar transistor).
b) Input Protection:	Input to inverter section shall be protected by fast acting fuses.

- c) Output Protection: Electronically controlled current limiting.
- d) DC Input Voltage Range: 300 - 450VDC
- 7. Waveform: Pure sinusoidal
- a) Output Transformer: Isolation type with vacuum impregnated windings.
- b) Logic Power Supply: Powered from battery and AC input, capable of supplying logic power from any one of these sources should the others fail.

2.6 STATIC BYPASS SWITCH

- A. Type: parallel
SCR's connected in a inverse configuration.
- B. Rating: to
The static switch shall be rated continuously carry 125% of the UPS's rated output. The static switch shall also be capable of carrying 1000% of the UPS's rated output for one cycle.

2.7 CONTROLS, INDICATORS AND ALARMS

- A. The front panel of the UPS shall have, as a minimum, the following indicators/alarms:
 - 1. LED Green: Load on inverter
 - 2. LED Green: Bypass within limits
 - 3. LED Yellow: Load on bypass
 - 4. LED Red: Overload
 - 5. LED Red: Overtemperature
 - 6. LED Red: Battery disconnected
 - 7. LED Red: Discharging
 - 8. LED Red: Low battery
- B. Metering: The UPS shall have an LED bar graph which shall indicate the amount of load on the UPS. The graph shall indicate 0 to 150% load, in addition a remote indications and control unit shall be provided.
- C. Audible Alarm: The UPS shall have an audible alarm plus remote alarm contact which shall enunciate when any alarm condition is present. A non-

latching "audible cancel" pushbutton shall be on the front panel to cancel audible alarm.

- D. Internal Temperature Monitoring: The temperature of all major power components such as the input and output transformers, rectifier, inverter and static power semiconductors shall be monitored for abnormal conditions; in the event of high component temperature, the UPS shall current limit and the inverter will shut down and cause a no-break transfer of the load to the static bypass AC source.
- E. Internal Indicators: The UPS shall be equipped with LED status indicators within the UPS for diagnostic evaluation:
1. LED Red: Bypass within limits
 2. LED Yellow: Sources synchronized
 3. LED Red: Bypass frequency failure
 4. LED Green: Load on inverter
 5. LED Red: Inverter voltage failure
 6. LED Red: General inverter failure
 7. LED Red: Load on bypass
 8. LED Green: PCB power supply present
 9. LED Red: Bypass overloaded

Contact Closures: The following contact closures shall be provided for remote wiring:

1. Alarm 1: On bypass
2. Alarm 2: Utility fail
3. Alarm 3: Low battery
4. Alarm 4: General summary alarm
 - Overloaded
 - Overtemperature
 - Battery disconnected

2.8 BATTERY

- A. Technology: Sealed, low maintenance (gel/cell type)
- B. Float Voltage: Factory preset. Float voltage is internally adjustable.
- C. Expected Service Life: 5 year at 0 -30 C ambient temperature
- D. Protection: Thermal magnetic circuit breaker.
- E. provide redundant D.C system (dual battery and dual charger).

2.9 MECHANICAL

- Enclosure: Free-standing floor mount design.

Mobility:

Casters and leveling feet shall be provided.

2.10 ACCESSORIES

The UPS system manufacturer shall provide, the following accessories:

- A. External maintenance bypass switch which shall allow for complete isolation of the UPS cabinet from the utility power and critical load. This shall allow for complete disconnection of the UPS cabinet for maintenance or repair. All transfers shall not effect load operation.
- B. Digital meter panel to display UPS input and output voltages, input and output currents, battery current and voltage.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which UPS is to be installed and notify Architect in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install complete UPS System, including associated by – pass switches control devices as indicated, in accordance with manufacturer's written instructions, requirements of applicable standards, and in accordance with local authority requirements to ensure that installation complies with requirements and serves intended function.
- B. Coordinate with other work as necessary to interface installation of UPS System with other work.
- C. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors.
- D. Anchor mounting hardware firmly to floors. To ensure enclosures are permanently and mechanically secured. Provide all hardware and accessories for proper mounting.
- E. Provide equipment earthing (grounding) connections for UPS System as required.

3.3 FIELD QUALITY CONTROL

- A. Upon completion of installation and after circuitry has been energized, demonstrate capability and compliance of UPS Systems with requirements. Where possible, correct malfunctioning units at site then retest to demonstrate compliance; otherwise, remove and replace with new units, and retest.

- B. Provide site testing by the manufacturer's field service personnel or representative. Site testing to consist of a complete test of the UPS Systems under load and the associated accessories supplied by the manufacturer. Document the test results, sign and date for Engineer.

3.4 PERSONNEL TRAINING

- A. Building Operating Personnel Training: Train Owner and operator's building personnel in procedures for starting up, bypassing and operating UPS System. Furnish operator's manuals providing installation and operation instructions for each UPS System .

END OF SECTION 10

SECTION 11

AUTOMATIC REACTIVE POWER COMPENSATION

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. Drawings and general provisions of Contract, including General and Special Conditions, apply to work of this section.
- B. Basic electrical materials and methods, section 16050 applies to work of this section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services and tests necessary to complete, make ready and set to work for operation by the Owner, automatic reactive power compensation in accordance with Drawings and Specifications.

1.3 QUALITY ASSURANCE

- A. Acceptable manufacturers: Firms regularly engaged in the manufacture of switchboards of the types and capacities required, whose products have been in satisfactory use in similar service for not less than 10 years as approved by the Engineer.
- B. Standards Compliance: Comply with requirements of applicable local codes and IEC 60831. Standards pertaining to automatic reactive power compensation assemblies.

1.4 SUBMITTALS

- A. Product data: Submit manufacturer's data for automatic power factor capacitor assemblies including sizes, enclosures, electrical ratings and characteristics and wiring diagrams.
- B. Shop Drawings: Submit dimensional layout on architectural background drawings of automatic power factor capacitor assemblies with related low tension, single-line diagram, and outline drawings.

PART 2 - PRODUCTS

2.1 RECOMMENDED MANUFACTURERS

Refer to list of recommended manufacturers.

2.2 GENERAL

- A. Provide fully automatic capacitor assemblies for low voltage applications as indicated on the plans and single line diagram.

- B. Each assembly (unit) shall provide 95% power factor correction with built in safeguards to prevent over capacitance.
- C. Assembly shall be fabricated as integrated part of the main low voltage switchgear.

2.3 RATINGS

- A. The voltage rating of the power factor correction equipment shall be 440 volts between phases.
- B. The total KVAR capacity of the assembly units shall be as indicated on drawings.
- C. The total KVAR shall be automatically switched in steps of 50 KVAR.

2.4 CAPACITOR CELLS - DRY TYPE

- A. Individual capacitors shall be self-healing utilizing polypropylene as a dielectric with vacuum deposited conductors on the polypropylene as electrodes.
- B. Each three phase capacitor shall be furnished with a approved pressure sensitive interrupter. The interrupter shall disconnect all three phases at the same time to maintain a balanced circuit.
- C. Capacitors shall be contained in hermetically sealed metal cans to prevent atmospheric contaminants from shortening the useful life.
- D. Dielectric material shall be low loss, less than 0.5 watts per KVAR.
- E. Dry cells encapsulation medium shall be a thermoplastic material which allows out gassing to engage the pressure interrupter.
- F. Terminal bushings shall withstand 10KV AC to ground and be rated 30 KV BIL or greater.
- G. Nominal design life of individual capacitor cells shall be 20 years.
- H. Individual capacitor cells shall be covered by a five year warranty.
- I. All capacitor cells shall have threaded terminals for wire connection.
- J. To reduce line transients on system no stage shall switch more than 100 KVAR and no capacitor cell shall exceed 25 KVAR.

2.5 CONTROLS

- A. All controls shall be mounted on enclosure door for easy inspection and service.
- B. A door interlock shall be provided to disconnect control power when enclosure door is opened.
- C. A personnel ground fault breaker shall be provided to disconnect control power upon accidental contact with control power and earth (ground).

- D. Reactive Power Controller/Power Factor Meter
 - 1. Controller shall measure the reactive current on every passage of the voltage through zero.
 - 2. A LED display shall be provided to indicate the stages that are on.
 - 3. To prevent leading power factor the controller shall be provided with a programmable target cosine selector.
 - 4. The time delay between switching of capacitors must be field programmable and have a range of 10 seconds to 10 minutes to reduce hunting and allow voltage decay as noted in par. 2.7.
 - 5. All output contacts shall be disabled within 15 milliseconds of main power interruption. The controller shall retain its programming after the restoration of supply voltage. The controller shall bring the capacitor bank back on line in a step, phased, normal sequence.
 - 6. Controller shall be able to select 1:1:1, 1:1:2, and 1:2:2 switching sequence of capacitor steps.
 - 7. Controller shall be able to display power factor with indication for an inductive or capacitive power factor.
- E. On-Off Switch
 - 1. On/Off switch shall control power to all door mounted controls.
 - 2. On/Off switch shall contain pilot light to indicate "on" mode.
- F. Blown Fuse Lights
 - 1. Three "Push-To-Test" blown fuse pilot lights, one per phase-door mounted, to indicate a blown fuse condition.
 - 2. Each fused phase, of each 50 KVAR step, shall have its own blown fuse indicating light mounted in close proximity to the fuse for easy identification.

2.6 GENERAL CONSTRUCTION

- A. All power wiring shall have a thermoplastic insulation rated for 105 degrees C.
- B. System wiring connections shall be made to copper bus bars braced for 65,000 amps or greater.
- C. Contactors shall be rated for switching of reactive current by the contactor manufacturer.
- D. The automatic power factor correction equipment shall be warranted by the manufacturer of the capacitor cells.
- E. Air core transient suppression coils shall be provided in series between the contactors and capacitor cells.

- F. All wiring connections shall be mechanically fixed with nut or screw.
- G. The automatic power factor correction shall be an expandable modular design.

2.7 DISCHARGE RESISTORS

- A. Capacitor "cells" shall be provided with discharge resistors to reduce residual voltage to less than 50 volts within one minute of de-energization, unless local codes govern otherwise.
- B. Resistors shall be chosen to insure a 20 year minimum life.

2.8 FUSES

- A. To provide for major fault protection, line fuses shall be provided on all three phases of each switched stage and fixed bank.
- B. Line fuses shall be current limiting, type. Minimum interrupting ratings shall be 200,000 amps for fuses of 30 amps and above.
- C. Fuses shall be designed for capacitor applications and shall be rated not less than 150% capacitor current rating.

2.9 PERFORMANCE FEATURES

- A. The capacitor shall be rated for continuous duty at 40 degree C ambient at 1,000 meters and below.
- B. Total Harmonic Distortion (THD) of 5% on either the voltage and current waveforms shall not effect the life of capacitors, contactors or controllers.
- C. A + 10% variation in line voltage shall not effect the life of the capacitor.

2.10 SYSTEM COMPATIBILITY

- A. Provide in each assembly, space and connections that if in the future, chokes and filters will be required, the installation can be accomplished in the field with minimum down time.

2.11 TESTING

- A. All capacitor cells shall be traceable through construction and testing.
- B. The automatic capacitor bank shall be tested for proper operation prior to leaving the factory. The following checks, measurements, and operations must be confirmed and recorded for each stage.

The certified record of these tests shall become part of the permanent documentation package that travels with the automatic capacitor bank.

- Wire Connections
- Torque Connections

- Phase to phase, Resistance Checks
- Controller Operation, Manual Operation
- Controller Operation, Automatic Operation

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which centralized automatic power factor capacitor assemblies are to be installed. Notify Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install centralized automatic power factor capacitor assemblies as indicated in accordance with manufacturer's written instruction, requirements of applicable standards, and in accordance with recognized industry practices to ensure that installation complies with requirements and serves intended function.
- B. Coordinate as necessary to interface installation of centralized automatic power factor capacitor assemblies with other works.
- C. Mount the switchboard assembly on flush steel aligning channels elevated above floor level by a concrete pad. Provide aligning shims to achieve level installation where channels can not be provided.
- D. Insure that centralized automatic power factor capacitor assemblies are shipped in sections which can be fitted through the structures and openings available.
- E. Bond together the centralized automatic power factor capacitor assemblies structure, sections to the switchboard earth bus and to the earthing (grounding) grid as required.
- F. Tighten electrical connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors.
- G. Provide 6.0 mm minimum thick x 100 cm wide insulation mat in front of centralized automatic power factor capacitor assemblies and rear of freestanding equipment and extend 30 cm beyond ends.
- H. Provide protective covering during construction.
- I. Touch up marred or scratched surfaces to match original finish.
- J. Provide control fuses, with five spare fuses for each rating.
- K. Adjust operating mechanism for free mechanical movement.

3.3 FIELD QUALITY CONTROL

- A. Upon completion of installation of equipment and after circuitry has been energized, test equipment to demonstrate compliance with requirements. When possible, field-correct malfunctioning units, then retest to demonstrate compliance; otherwise remove and replace with new equipment and retest.
- B. Prior to energization of switchboards and centralized automatic power factor capacitor assemblies:
 - 1. Perform insulating resistance test on each pole, phase-to-phase and phase-to-earth for (1) minute. Minimum test voltage to be 1,000 volts D.C. with a minimum resistance of 100 megohms.
 - 2. Check centralized automatic power factor capacitor assemblies for continuity and for short circuits.
 - 3. Notify Engineer of any abnormalities.
- C. After assemblies are energized, demonstrate functioning in accordance with manufacturers requirements.

3.4 MAINTENANCE

- A. All maintenance and inspection on the capacitor assembly shall be done with the system disconnect device in the open position.
- B. Maintenance and inspections should be limited to 15 minutes or less so not to affect utility billing.
- C. An annual inspection of the capacitor cell shall be done to identify failing capacitor cells (a bulged cover is the symptom to watch for).

END OF SECTION 11

SECTION 12

MEDIUM VOLTAGE SWITCHGEARS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions (General requirements), apply to work of this section.
- B. General Provisions for Electrical Work, Section 16050, applies to work of this section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, M.V switchgears in accordance with Drawings and Specifications.

1.3 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in the manufacture of switchgear of the types and capacities required, whose products have been in satisfactory use in similar service for not less than 10 years.
- B. Standards Compliance: Comply with requirements of applicable local codes and IEC 60529, Standards pertaining to M.V switchgears.

1.4 SUBMITTALS

- A. Product data: Submit manufacturer's data for switchgears including sizes, enclosures, and electrical ratings and characteristics.
- B. Shop Drawings: Submit dimensional layout on architectural background drawings of switchgear, single-line diagram, and outline drawings.

PART 2 - PRODUCTS

2.1 RECOMMENDED MANUFACTURER

Refer to list of recommended manufacturers.

2.2 11 KV SWITCHGEAR

A. GENERAL

The 11 KV switchgear shall be of the metal clad indoor type, type tested, completely wired and tested at the factory, ready for installation when received on site. Site work shall be limited to inter-unit wiring only.

The following parts of the equipment shall comply with the relevant I.E.C.62271-1 Standards specification regarding design, workmanship and testing.

- | | | |
|----|--------------------------------|---------------------|
| 1. | Circuit-breakers | (I.E.C. 62271-100). |
| 2. | Metering and protective C.T.'S | (I.E.C. 60044-1). |
| 3. | Metering and protective V.T.'S | (I.E.C. 60044-2). |
| 4. | Relays | (I.E.C. 60255). |
| 5. | Disconnect & earthing switches | (I.E.C. 60271-102). |
| 6. | High voltage fuses | (I.E.C. 60282-2). |

Precaution shall be taken at contacts between aluminum and other material to avoid electrolytic action.

All circuit-breakers on the 11KV switchgear shall be interchangeable.

The switchgear shall be constructed so that it corresponds to the degree of protection IP 42 according to IEC publication No. 60529.

B. SWITCHGEAR ARRANGEMENT (FOR ARRANGEMENT SEE DESIGN DRAWINGS)

The switchgear shall be of the metal clad indoor type, of size, rating and arrangement as shown on Drawings and indicated in the Specification. The complete assembly shall be floor mounted, free standing, with matching cases, to form a continuous integral structure. The housing shall consist of folded sheet steel sections welded together and shall be of robust construction. Switchgear shall have front and rear access.

- C. Direct panel to panel busbar connection shall be made without the use of interconnecting links.
- D. The arrangement shall permit cables to enter from the bottom or top of the enclosure as indicated on the drawings and connect at their respective terminals without interference.
- E. Cable termination shall be provided for incoming and outgoing feeders having 3-core, armoured XLPE insulated, Aluminium cable of 240 mm² cross section area.
- F. All wiring, necessary fuse blocks and terminal blocks within the switchgear as required, all groups of control wires leaving the switchgear with terminal blocks with suitable numbering strips.
- G. All exterior and interior steel surfaces of the switchgear properly cleaned and finished with electrostatic painting over a rust-inhibiting phosphatized coating suitable for the climatic conditions of the site.
- H. Engraved Nameplates: For feeder circuits including control fuses and for all indicating lights and instruments, indicating item designation and circuit number as well as frame ampere size and appropriate trip rating; master nameplate giving switchgear designation, voltage ampere rating, short circuit rating, manufacturer's name, general order number and item number; feeder nameplates of the screw on type, cardholders are not acceptable.

- I. Bus bars's connections shall be made of Silver plated copper, rated for continuous amperes as scheduled or shown and to withstand maximum short-circuit stresses for a period of one second when connected to the 11 KV utility supply system having a fault capacity of 500 MVA or as indicated on the drawings at rated voltage.

2.3 OVER CURRENT DEVICES

- A. Feeder Protective Devices: SF6 type circuit breakers type with ratings as shown on the drawings and have additional characteristics as specified.
- B. Circuit - Breaker :

1. General Requirements

Circuit-breaker shall be capable of making, breaking and carrying the specified load current continuously under on-site environmental conditions.

Circuit-breaker closing mechanisms shall be trip-free with momentary full closing of contacts.

1.1 Independent Manually Charged Spring Operation

Closing of circuit-breakers shall be by independent charged spring operation, springs shall be charged manually.

It shall be possible to charge the springs while the circuit-breaker is closed, ready for the next closing operation.

1.2 Independent Motor charged Spring Operation

Closing of circuit-breaker shall be by independent motor charged spring operation. A separate manual charging mechanism shall be provided in case of supply failure. It shall be possible to charge the springs while the circuit-breaker is closed, ready for the next closing operation.

All auxiliary switches shall be wired to a terminal block on the fixed portion of the switchgear, whether the switches are in use or not.

A positively driven position indicating device shall show the appropriate contact position of the circuit-breakers.

An indicating device shall show the state of charge of the operating springs.

A non-resettable operations counter shall be fitted.

- 1.3 A capacitor trip device shall be provided with the circuit breaker shunt trip to ensure that energy will be available for tripping during fault conditions. A control power transformer is required on the source side of the circuit breaker. This control

power transformer shall have sufficient capacity to supply other AC auxiliary power requirements for the switchgear.

2. Circuit Breakers (A/C type)

Circuit-breakers shall be single break with parallel main and arcing contacts in a gas-filled sealed insulated enclosure. On opening, the main contacts shall part first, transferring the current to the arcing contacts to minimize wear on the main contacts.

Arc extinction shall be achieved without the use of external gas reservoirs. Compressors shall not be used.

Circuit-breakers that operate with gas pressure above atmospheric, shall incorporate a low pressure detector with alarm and/or lock-out facility as specified in the schedules.

C. Disconnecters and Earthing Switches

Disconnecters and earthing switches shall comply with IEC standards.

Disconnecters and earthing switches shall be capable of breaking negligible current but capable of carrying full fault current stated in the schedules for a minimum of 1 second.

The earthing switch must be of full making capacity in event of accidental closing on a line circuit.

Interlocks shall be provided to prevent disconnecters and earthing switches from being closed when the system is energized and to prevent disconnecters switches being opened with the system is energized.

D. Each switchgear unit shall be provided with a metal rating and name plate giving the required particulars in accordance with the IEC recommendations.

E. Instruments and meters shall be of the flush pattern type with phenolic-black finish.

F. Relays shall be microprocessor type with integrated metering and diagnostic LCD display and equipped with RS-485 communication port.

Test terminal blocks shall be provided for all instruments, relays ...etc.

G. Incoming Feeder Panels :

Shall be equipped with the following components :

- One withdrawable, motor operated, circuit breaker rated 630 A, with 500 MVA short circuit breaking capacity
- One set of busbars rated 630 A and designed to withstand electrodynamic forces under worst short circuit conditions of 500 MVA.

- | | | |
|----------------|---|---------------------|
| Accuracy class | : | CL 0.5 for metering |
| | : | 5P10 for protection |
| Ratio | : | 400/5/5 A |

- Ratio 11000 / 110 / 110
 $\sqrt{3}$ $\sqrt{3}$ 3

- #### H. Outgoing Feeder Panel :

- One withdrawable, motor operated, circuit breaker rated 630A, with 500MVA short circuit breaking capacity.
- One set of insulated busbars rated 630A, and designed to withstand electrodynamic forces under worst short circuit conditions of 500 MVA.
- Three current transformers with separate secondaries for protection.

Ratio	:	150/5/5 for outgoing transformers and 300/5/5 for ring loops
Accuracy class:	:	CL 0.5 for metering 5P10 for protection

- 5

- Earth leakage relay.
- Digital multimeter (currents, voltage, KWH, KVAR, KVA, power factor, maximum demand,etc).
- Relay characteristic must be coordinated and approved by electric power authority.
- Earthing switch.
- Space heater.

I. Bus Sectionalizer Panel :

Shall be equipped with the following components.

- One withdrawable, motor operated, circuit breaker rated 630 A, with 500MVA short circuit breaking capacity.
- One set of insulated busbars rated 630A, and designed to withstand electrodynamic forces under worst short circuit conditions of 500MVA.
- Three current transformers with separate secondaries for protection and metering.

Ratio	:	300/5/5
Accuracy class:	:	CL 0.5 for metering
	:	5P10 for protection
- One three phase non directional over current relay, with instantaneous short circuit element and definite time characteristic.
- Digital multimeter (currents, voltage, KWH, KVAR, KVA, power factor, maximum demand,etc).
- Relay characteristic must be coordinated and approved by electric power authority.
- Earth leakage relay.
- Space heater.

2.4 RING MAIN UNITS:

A- GENERAL:

- a- Four each ring main unit rating and arrangement refer to design drawings.
- b- Cable termination boxes shall be provided for the incoming and outgoing, also for the feeder to the 11 KV switchboard, having the following characteristics :

- Incoming and outgoing feeders, to be as used by the Electric Power Distribution company, coordinate with local power authority in this respect.
- The 11 KV switchboard feeder, 3-Core, XLPE insulated armoured with 240 sq.mm. Aluminum conductor.
- c- Provision for CED metering must be provided complete with current and voltage hardwires necessary for KWH & KVARH metering connections from incomers of MVSWG-H1 to RMU's H1 & H2.
- d- Outgoing SF6 circuit breakers for ring main units shall be withdrawable motor operated 11 KV, 630 A, 500 MVA short circuit breaking capacity complete with current transformer and voltage transformers and digital protective relay.
- e- The SF6 circuit breakers shall be equipped to receive an external voltage free tripping signal from over temperature protection control devices installed at transformers.

B- TECHNICAL DATA:

The ring-main-unit shall fulfill the following data :

- | | | | |
|----|---|---|---|
| a. | Type | : | SF6 gas insulated with all main busbars to be housed in SF6 gas insulated enclosure |
| b- | Rated voltage | : | 11 Kv |
| c- | Rated current : | | |
| | - Ring main load break switches | : | 630 A. |
| d- | Short circuit level | : | 500 MVA at 11KV. |
| e- | Impulse withstand voltage
1.2/50 sec (KV Peak) | : | 95 KV. |
| f- | Rated insulation level, one minute
Withstand voltage, 1 min., 50 Hz. | : | 35 KV |
| g- | Earth leakage indicator | : | Required |
| h- | Space heater | : | Required |

C- GENERAL REQUIREMENTS

- a- Nameplate: Mounted on the front door; in addition, mount a "Danger 11,000 Volts" sign in English and Arabic, on all doors providing access to medium voltage ring main unit space.

- b. Supply key interlocks as directed by the Utility Co.
- c. Entire ring main unit to be in complete compliance with the Utility Co's. requirements and standards. Obtain Utility approval of the ring main unit prior to fabrication and exact location prior to installation.

2.5 PARALLELING SWITCHGEAR

A. GENERAL

1. The paralleling switchgear at 11 KV level shall be manufactured and furnished in accordance with the requirements of manufacturer of the emergency power generator so as to maintain system compatibility and local service responsibility for the complete electric generating system.
2. Construction shall be of a rigid, free-standing, metal- enclosed structure and shall contain, but not be limited to following :
 - a) All devices specified herein and as required to perform the described functions.
 - b) One (1) paralleling switchboard section for each generating set in the system.
 - c) One (1) totalizing switchboard section for every outgoing the system.
 - d) Distribution section as shown on drawings containing over current devices, Air circuit breaker and other devices as shown and as specified herein.
3. The switchboard shall be constructed of sheet steel with suitable steel framework, however, totalizing and distribution sections should be wide enough to accommodate the devices shown. Paralleling switchgear shall be bused together by full-sized horizontal bus extending through full width of all sections (entire length of switchgear).
4. The degree of protection shall be IP 54.

Busbars shall be silver plated, 3-phase buses with one-half neutral and one half earth bus. Bus temperature rise shall not exceed 40 C over the internal ambient. Bus shall be braced for the peak asymmetrical current available from all generating sets plus motor contributions. Access to bus and breaker terminals for generator connections shall be through removable front panels. Space shall be provided at front of switchgear. Components shall be mounted in a metal enclosed area behind locking front doors. All wiring shall be sized as required but not smaller than 2 mm.sq. Each device or function shall be suitably identified by silk-screen or similar permanent identification.

B. PARALLELING SWITCHBOARD SECTIONS

1. Rating: Each paralleling switchboard section shall have KW rating equal to or greater than KW rating of corresponding engine-generator set at 0.8 PF, as specified elsewhere in this specification. Metering shall read to approximately 125% of switchboard rating.
2. Controls and metering: Each paralleling switchboard shall contain the following controls and meters. All control switches not otherwise specified and all indicator lights shall be oil tight with snap-on contact blocks:
 - a) Frequency meter 55-65 Hz. 250 degree scale 1% switchboard meter.
 - b) AC voltmeter, 250 degree scale 1% switchboard meter.
 - c) AC, 3-phase wattmeter, 250 degree scale 1% switchboard meter.
 - d) Three AC ammeters, 250 degree scale 1% switchboard meter.
 - e) Running time meter for 9,999.9 maximum reading in hours.
 - f) Voltmeter phase selector switch to read line to line 3 phases on generator with off position.
 - g) Reset switch to reset controls after load shed or engine malfunction.
 - h) Lamp test switch to simultaneously test all indicator lamps.
 - i) Indicator lamps for following :
 - i. Fail to synchronize-amber (sounds alarm)
 - ii. High Engine temperature pre-alarm-amber (sounds alarm)
 - iii. Low oil pressure prealarm - amber (sounds alarm)
 - iv. Low engine temperature-amber (sounds alarm).
 - v. Overcurrent lockout-red (stops unit, sounds alarm).
 - vi. Exciter overcurrent-red (stops unit, sounds alarm).
 - vii. Reverse power-red (stops unit, sounds alarm)
 - viii. High engine temperature-red (stops unit, sounds alarm)
 - ix. Low oil pressure-red (stops unit, sounds alarm)
 - x. Overcrank-red (stops unit, sounds alarm).
 - xi. Overspeed-red (stops unit, sounds alarm).
 - xii. Overvoltage-red (stops unit, sounds alarm).

- xiii. Automatic mode-green.
 - xiv. Manual mode-red.
 - xv. Breaker open-green.
 - xvi. Breaker closed-red
 - xvii. Control locked out-red (sounds alarm).
 - xviii. [D.C. Voltage-red (sounds alarm), complete with D.C voltage sensor]
- j) Auto-off-run selector switch. Alarm to sound when switch is in OFF position.
 - k) Manual operator switch for circuit breaker, with mechanical target to indicate last operated position.
 - l) Frequency adjust potentiometer.
 - m) Voltage adjust potentiometer.
 - n) Synchroscope switch for control of synchroscope on totalizing switchboard.
 - o) Power factor meter 1% accuracy.
 - p) Reverse power relay test circuit with pushbutton switch on front.
3. Components : Each paralleling switchboard shall contain the following components :
- a) Contact making device to close on failure of engine- generator to be used for load shedding controls in the totalizing section. Contacts to remain closed until manually reset by operating reset switch.
 - b) Electronic governor control panel and load sharing module for isochronous load sharing and for control of electronic governors on the engine-generator sets.
 - c) First start sensor with automatic mode permissive relay to connect first set to reach approximately 90% of rated frequency and voltage to the emergency bus. The first start sensors for each set shall be solid- state and be sequentially enabled. The first start sensor shall positively prevent out-of-phase paralleling if two sets reach operating conditions simultaneously and shall include redundant circuitry to ensure operation, even if the primary system is disabled. Systems using dead bus relay schemes without a disable signal to positively prevent out-of- phase paralleling shall not be acceptable under this specification.
 - d) Reverse power relay to sense a condition of reverse power flow through the generator breaker and open the breaker when the

reverse power exceeds a presettable level for a given time period. Unit will be shutdown.

- e) Synchronizer to electronically adjust the engine governor to match the frequency and phase angle of the bus.

Synchronizer shall maintain engine at same frequency as bus and within 20 degrees of bus for 0.5 seconds before closing breaker. Each unit shall have its own synchronizer, systems using a switching scheme (or relays) to utilize the same synchronizer to operate with more than one engine-generator set shall not be acceptable under this specification.

- f) Permissive paralleling relay to prevent out-of-phase paralleling during manual operation. This shall be accomplished by a device separate from synchronizer, but phase angle, frequency, and time requirements are same for breaker closing.
- g) Control modules shall provide a system of diagnostic light emitting diodes (L.E.D.'s) to assist in analyzing proper functioning of system, consisting of : "first on Line", "In Phase", Emergency Buss ON", "Generator ON".
- h) Generator main circuit breakers shall be 3-pole, single-throw, electrically-operated power air circuit breakers with D.C. under voltage trip and stored energy closing system for 5-cycle closing time. Breakers shall be 2000 amp. frame . Trip units shall have adjustable long delay, short delay, and instantaneous trip settings and shall be adjusted per engineer recommendations for best coordination, ground fault trips are not required.

Breakers shall have enough auxiliary contacts and overcurrent trip switch Provide mechanical type solderless lugs for cables from generator sets to circuit breakers. Breakers shall be bus connected to main horizontal switchgear bus.

- i) Pulse alarm system to sound alarm at first fault and at each subsequent fault. Requires pulse alarm adder to totalizing section.

4. TOTALIZING SWITCHBOARD SECTION

- a) Rating : Kilowatt rating of switchboard shall be approximately 125% of the total available power from the specified engine-generator sets. Metering shall read to 100% of the switchboard. rating.
- b) Controls and Metering : The totalizing switchboard shall contain the following controls and meters. All control switches not otherwise specified and all indicator lights shall be oil tight with snap-on contact blocks :
 - i. AC voltmeter to monitor bus voltage, 250 degree scale, 1% switchboard meter.

- ii. AC, 3-phase wattmeter to monitor bus power, 250 degree scale 1% switchboard meter.
 - iii. Three AC ammeters to monitor bus current, 250 degree scale 1 % switchboard meter.
 - iv. Voltmeter phase selector switch.
 - v. Test-Normal selector switch.
 - vi. Lamp test switch.
 - vii. Alarm horn and silence switch.
 - viii. Indicator lamps for following :
 - Major fault-red (sounds alarm).
 - Minor fault-amber (sounds alarm).
 - Non-Automatic-red (sounds alarm).
 - Normal source failure-red.
 - System test-red.
 - Cool down period-green.
 - [Load shed-red (sounds alarm)]
 - [Exercise Mode-red].
 - ix. Power factor meter 1% accuracy.
 - x. Synchroscope and paralleling light swing out panel with control switch on each paralleling switchboard.
- c) Components : The totalizing switchboard shall contain the following components:
- i. Load shedding control the load shedding control shall be a logic circuit with outputs to control the reduction of system load after failure of any engine generator set. It shall accomplish this function by continuously monitoring the fault circuitry of each engine generator set. If one set fails, the lowest priority load shall be shed. If additional failures occur, additional priority levels will be shed. this control shall provide 3-isolated N.O. (convertible to N.C.) contacts (rated 10A at 600 V) for each level. These contacts shall be used to control operation of load shed devices, such as automatic transfer switches, shunt trip circuit breakers or switches, electrically operated circuit breakers, magnetic contactors, magnetic motor starters, and/or any devices shown on drawings or

specified herein to shed necessary load in the distribution system.

- ii. This system shall use the load shedding transfer switches as the load shed devices, by electrically driving certain transfer switches to a neutral position upon load shed signal. The switches shall automatically reconnect the load to the normal source only after full service has been restored to normal side of transfer switch. If the failed generator set is returned to bus, the switches shall return to generator bus (unless normal utility power has been restored).

Coordinate the shedding priority with the Engineer.

- iii. System starting controls to signal each paralleling switchboard to start engine-generator sets.
- iv. Time delay on starting 1.5 to 15 sec. adjustable time delay on pickup. All units must start simultaneously.
- v. TD cool down run in parallel - 3 to 30 minutes adjustable time delay on dropout. All units must stop simultaneously.
- vi. Exerciser clock (2-week type) to automatically start and parallel the generator sets and allow them to run for a preset time.
- vii. Alarm II system to operate with pulse alarm in each paralleling switchboard. This alarm system shall operate audible and visual alarm at first fault and at each subsequent fault.
- viii. Load add override feature with switch and indicator lamp to allow manual override of load shed controls.
- ix. Underfrequency sensor to operate on adjustable underfrequency settings, operation shall cause load shedding of lowest priority load and sounding of alarm. Provide "underfrequency Load Shed" indicating lamp and reset switch.
- x. Priority override switch for manual override of priority control to allow manual pickup of loads in case of failure to start of one engine-generator set in system.
- xi. Load demand starting feature for 2-engine-generator sets. This feature provides for starting and stopping of engine-generator sets connected to the bus in response to the load connected to the switchgear bus. Provide "Load Demand Mode" indicator lamp and control switch. Provide "Lead Unit" selector switch.
- xii. Provide load cable terminations with NEMA standard mechanical type lugs for load cables, sized as shown on the drawings.

- xiii. Distribution Section : The switchgear shall include distribution section, similar in construction to that specified for the paralleling switchgear, and shall contain a full size extension of the horizontal main bus and vertical riser [bus as needed to connect the distribution section devices to the main bus. Riser bus shall be tinned copper bus and shall be sized to meet temperature rise requirements as specified for main bus]

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which switchgears are to be installed. Notify Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected.
- B. Routine work tests shall be carried out at the manufacturer's works in the presence of the Owner's consultant.

3.2 INSTALLATION

- A. Install switchgear as indicated in accordance with manufacturer's written instruction, requirements of applicable standards, "Standard of Installation," and in accordance with recognized industry practices to ensure that installation complies with requirements and serves intended function.
- B. Coordinate as necessary to interface installation of switchgear with other work.
- C. Mount the switchgear assembly on floor steel aligning channels elevated above floor level by a concrete pad. Provide shims to achieve level installation.
- D. Insure that switchgear are shipped in sections which can be fitted through the available structures.
- E. Bond together the switchgear structure, sections and all conduits terminating at same with a 120mm² bare copper earth cable and connect to the switchgear earth bus and to the earthing loop as required. Provide conduits terminating at switchgear with Earthing Wedges of the required size.
- F. Tighten electrical connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques.
- G. Provide fuses of the ratings indicated, with one complete set of spare fuses for each rating.
- H. Adjust operating mechanism for free mechanical movement.
- I. Provide 6.0 mm minimum thick × 60 cm wide insulation mat in front of Medium voltage switchgear, ring main units and rear of freestanding equipment and extend 60 cm beyond ends

3.3 FIELD QUALITY CONTROL

- A. Upon completion of installation of equipment and after circuitry has been energized, test equipment to demonstrate compliance with requirements. When possible, field-correct malfunctioning units, then retest to demonstrate compliance; otherwise remove and replace with new equipment and retest.
- B. Prior to energization of switchgears:
 - 1. Megger check phase-to-phase and phase-to-ground insulating resistance levels of conductors.
 - 2. Check switchboard for continuity and for short circuits.
- C. Set all circuit breaker trip rating for maximum coordination with upstream and downstream devices, including ground fault trips where supplied.
- D. Subsequent to wire and cable hook-ups, energize equipment and demonstrate functioning in accordance with requirements.
- E. Open and close load break switching devices under load.

3.4 PERSONNEL TRAINING

- A. Building Operating Personnel Training : Train Owner's building personnel in procedures for starting up, testing and operating M.V. switchgear and auxiliary equipment. Furnish three operator's manual providing installation and operating instructions for the M.V. switchgear.

END OF SECTION 12

SECTION 13

DISTRIBUTION TRANSFORMER

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions (General requirements), apply to work of this section.
- B. General Provisions for Electrical Work, Section 16050, applies to work of this Section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services and tests necessary to complete and make ready for operation, all wiring devices in accordance with drawings and specifications.

1.3 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in the manufacture of transformers of the types, and capacities required, whose products have been in satisfactory use in similar service for not less than 10 years.
- B. Standard Compliance: Comply with requirements of applicable local codes, IEC and EN. Standards, pertaining distribution transformers. Provide transformer products and components which have been listed and labeled.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's data for transformer including, size enclosures, and electrical ratings and characteristics.
- B. Shop Drawings: submit dimensional layout on architectural background drawings of transformers, single-line diagram, and outline drawings.

PART 2 - PRODUCTS

2.1 RECOMMENDED MANUFACTURERS

Refer to list of recommended manufacturers.

2.21 GENERAL

- A. The transformer shall be oil type designed, manufactured, constructed and tested in accordance with IEC 60076 standards as are relevant, except where modified by this specification.
- B. The transformers must be of low loss type per local Electricity Distribution Co., requirements.

- C. Transformers in the context of this specification shall comprise assemblies of a magnetic core, primary and secondary windings, supporting framework and terminal boxes.
Unless otherwise specified transformers shall comply with IEC 60726.
- D. The design, manufacture, selection, installation, testing, commissioning and subsequent maintenance of all equipment and materials described in this specification shall comply with the requirements of, the electricity at work regulations and the IEE wiring regulations.
Where more requirements are specified herein, the conditions of this specification shall take precedence.

2.3 DESIGN REQUIREMENTS:

- A. The transformer shall be of the oil filled type as specified
- B. The transformer may be equipped with external panel coolers. The unit shall deliver full rate capacity with a temperature rise not greater than 65 °C at specified ambient temperature. Audible sound level shall not be greater than 60 db.
- C. The transformer's shall be manufactured according to I.E.C. Standards, publication No. 60076, parts 1 to 5 inclusive.
- D. The transformer's core shall be built up from grain oriented stress relieved cold-rolled silicon sheet steel lamination insulated on both sides. The windings are to be of copper conductors insulated with high dielectric strength-tapes, having very good temperature stability. The windings shall be firmly braced to avoid loosening them due to short circuit.
- E. The HV and LV terminals together with the neutral shall be brought outside the transformer's tank through proper bushings arranged according to specifications.
- F. The no-load tap changer shall be mounted on the tank cover and the different position are to be identified.
- G. The transformer tank shall be made of sheet steel and so designed to increase the cooling surface area.
- H. It shall be so rigid to withstand the mechanical stresses expected during transportation.

2.4 PERFORMANCE

A. GENERAL

The transformers shall comply with the requirements of IEC 60726 in respect of partial discharge, impulse withstand short circuit strength.

B. LOSSES

Losses at no-load and loaded conditions shall be the lowest achievable for the transformer type specified per local Electricity Distribution Co., requirements.

2.5 HANDLING FACILITIES

A. LIFTING

Transformers shall be provided with permanently fitted lifting lugs or eye bolts to facilitate handling by crane or hoist.

B. FRAME WHEELS

Transformers shall be designed for floor mounting and be provided with removable bi-directional or steerable rollers.

The rollers shall be lockable or means provided to prevent movement of the transformers after installation.

2.6 CONNECTION FACILITIES

A. CONNECTION METHODS

Connection methods shall comply with IEC 60076-4. Provision shall be made by the manufacturer for the mounting and connection of cable boxes and/or busbars as specified for the H.V. and L.V. conductor connections.

Where HV and LV cable boxes and/or busbars are specified these shall generally be arranged on opposite sides of the transformer. However exact positions shall suit the specified requirements of each individual situation.

LV cable terminations shall be kept separate from the HV cable connections and insulated to the specified voltage and able to withstand the specified short circuit currents.

All HV coil interconnections shall be insulated for the specified voltage, and able to withstand the specified short circuit currents.

An earthing terminal shall be provide at a convenient point on the supporting steel work. All steel work shall be bonded to the earthing terminal if it is not electrically continuous. Provision shall be made for making an earth connection to the neutral of the LV windings, should this be required.

B. TERMINAL MARKINGS

H.V. and L.V. winding terminals shall be clearly marked with characters in accordance with IEC 60076-4. The characters shall be stamped or engraved on securely fixed, durable and non-corrodible plates.

2.7 TAP CHANGING FACILITIES

A. TAP CONNECTIONS AND LINKS

Each transformer shall be provided with tapping on the HV winding to cater for supply voltage variations in the range $\pm 2 \times 2.5\%$ in compliance with IEC 60076-4.

Tap changing shall be effected by off-circuit tapping links.
A visible warning notice shall be fixed adjacent to the tapping links and worded as follows:

<p>"WARNING - OFF LOAD TAP CHANGING LINKS - ISOLATE HV AND LV SUPPLIES TO TRANSFORMER BEFORE OPERATION"</p>

2.8 THERMAL PROTECTION

Each transformer shall be provided with a system of thermal protection and temperature monitoring.

Temperature sensing thermistors shall be mounted in each LV coil as close as practicable to its hot spot. The thermistors shall be wired back to an electronic controller fitted on the transformer.

The thermistors shall be used to indicate winding temperature, and provide alarm and trip indications, and to operate room fans and trip HV circuit breakers where specified. Volt-free contacts shall be provided for relaying signals to remote equipment.

Wiring from the thermistors to the temperature controller shall be carried out with single core copper cables to DIN/VDE standards with LEF insulation. Cables shall be contained in galvanized steel conduit supported from the transformer steel work.

The temperatures at which the room exhaust fans shall be switched on and off shall be adjustable within preset limits.

2.9 ACCESSORIES

Provide the following accessories with each transformer

- Expansion conservator.
- Draining and sampling valves.
- Oil level indicator.
- Buchholz relay.
- Dehydrating breather.
- Dial Thermometer.
- Cable end boxes.

2.10 TESTING INSPECTION AND COMMISSIONING

A. FACTORY TESTS

Factory tests as called for in IEC 60726 shall be carried out on each transformer at the manufacturers works in the presence of the Engineer.

The tests to be carried out shall include but not necessarily be limited to :

- (i) winding resistance on nominal tapping
- (ii) voltage ratio and vector relationship

- (iii) load loss and impedance
- (iv) no-load loss and current
- (v) induced over voltage test at 2 times rated voltage
- (vi) insulation resistance
- (vii) partial discharge at 1.3 times nominal voltage.

The works tests shall comply with the requirements of this Specification.

B. SITE TESTS

All site tests shall be carried out in accordance with this Specification.

After delivery to site each transformer shall be inspected in the presence of the Owner's consultant, prior to installation.

After installation each transformer shall be tested and inspected in the presence of the engineer.

The HV and LV winding connections shall be demonstrated as providing the specified polarity and phase rotation and tap connections.

The HV and LV windings shall be tested for continuity and insulation resistance with a 1000 V insulation tester. The insulation resistance between adjacent windings shall not be less than 100 M ohm.

After the HV windings are energized, it shall be demonstrated that the voltage and phase rotation at the LV terminals are as specified.

2.11 TECHNICAL REQUIREMENTS

HV Supply side	11000 Volt
. Number of phases	3 phase
. Fault level (nominal design)	500 MVA
LV Supply side	
. No-load voltage	400 V
. Number of phases	3 Phase
. Rating	As shown in plans.
Supply frequency (HZ)	50 HZ
HV winding connection	DELTA
LV winding connection	STAR
Vector group reference	DYn 11
Impedance at 75°C	6 %
HV Tapping (% of no-loads volts)	± 2% x 2.5%
HV Insulation level	12 KV
. Impulse KV peak	95 BIL
. Power frequency (KV RMS)	35 KV
HV conductor and type	Top entry cables
LV conductor and type	Top entry cables
Indoor or outdoor installation/space limitations	Indoor - refer to layout See design drawing
coil material (HV)	Copper.
coil material (LV)	Copper.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which transformers are to be installed. Notify Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install transformers as indicated in accordance with manufacturer's written instructions, requirements of applicable standards, and in accordance with Utility Co. and local authority requirements to ensure that installation complies with requirements and serves intended function.
- B. Coordinate as necessary to interface installation of transformers with related switchboards and other work.

- C. Tighten electrical connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors.
- D. Provide protective covering during construction.
- E. Touch-up marred or scratched surfaces to match original finish.
- F. Adjust fans when so furnished for free mechanical movement.

3.3 FIELD QUALITY CONTROL

- A. Upon completion of installation of equipment, and after circuitry has been energized, test equipment to demonstrate compliance with requirements. Where possible, correct malfunctioning units, then retest to demonstrate compliance; otherwise, remove and replace with new equipment and retest at no additional cost to Owner.
- B. Prior to energization of transformers and related distribution equipment:
 - 1. With manufacturers approval, perform phase-to-phase and phase-to-earth insulation resistance tests utilizing a megohmmeter with minimum test voltage output of 5,000 volts DC with a minimum resistance of 25,000 megohms. The test duration shall be for 10 minutes with resistance tabulated at 30 seconds, (1) minute and 10 minutes. Dielectric absorption ratio and polarization index will be calculated.
 - 2. Check transformers for continuity and for short circuits.
 - 3. Notify the Engineer of any abnormalities.
- C. Subsequent to wire and cable hook-ups, energize transformers and demonstrate functioning in accordance with requirements.
- D. Provide manufacturer's recommended DC high potential test for transformers and verify acceptability of results prior to energizing.

END OF SECTION 13

SECTION 14

SWITCH DISCONNECTORS (ISOLATORS)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions (General requirements), apply to work of this section.
- B. Basic electrical materials and methods, section 16050 applies to work of this section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, all switch disconnectors in accordance with Drawings and Specifications.

1.3 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in manufacture of switch disconnector of types and capacities required, whose products have been in satisfactory use in similar service for not less than 3 years. Provide safety and motor disconnects produced by a manufacturer listed as an Acceptable Manufacturer in this section.
- B. Standards Compliance: Comply with requirements of applicable local codes, IEC 60974-3 pertaining to switch disconnectors.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's data including printed technical literature, installation, instructions, and catalog cuts for each type of switch disconnectors.
- B. Samples: submit sample of each range of the switch disconnectors.

PART 2 - PRODUCTS

2.1 RECOMMENDED MANUFACTURER

Refer to list of recommended manufacturers.

2.2 SWITCH DISCONNECTORS

A. SWITCH INTERIOR

- 1. Switchblades fully visible in the OFF position when the door is open.
- 2. Removable arc suppressor where necessary to permit easy access to line side lugs.

3. Industry listed lugs for copper cable and front removable.
4. Plate all current carrying parts.
5. Solid neutral where required

B. SWITCH MECHANISM

1. Heavy duty load break type 3 poles.
2. Rating: Voltage, poles, amperes, horsepower, and maximum available fault current as required or shown on drawings.
3. Quick-make and quick-break operating handle and mechanism integral with the box, not the cover.
4. Defeat able dual cover interlock to prevent inadvertent opening of the switch door in the ON position or closing of the switch mechanism with the door open.
5. Handle position to indicate if switch is ON or OFF.
6. Provision for padlocking handle.

C. ENCLOSURE

1. In decorative areas shape and colour as approved or requested by the Engineer.
2. In technical areas industry Standard heavy duty with metal enclosure and multiple knockouts on all sides and back.
3. Hinged door and cover.
4. Industry Standard for exterior installation with protection class IP 55.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which safety and switch disconnectors are to be installed. Notify Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install switch disconnectors as indicated, in accordance with manufacturer's written instructions, requirements of applicable Standards, and in accordance with recognized industry practices to ensure that installation complies with requirements and serves intended function.
- B. Coordinate as necessary to interface installation switch disconnectors with other work.

- C. Protect switch disconnectors from dirt, moisture and construction debris, subsequent and during installation until project is accepted by Owner.
- D. Tighten connectors and terminals, including screws bolts and equipment grounding connections in accordance with equipment manufacturer's published torque tightening values for equipment connectors.
- E. Install switch disconnectors used with motor-driven appliances and motors and controllers within sight of controller position unless otherwise indicated.
- F. Provide box with spare set of each size fuse used on project. Provide nameplate on switch, indicating equipment served.
- G. Install fuses in fused switches.
- H. Provide equipment grounding connections, sufficiently tight to assure a permanent and effective ground, for electrical switch disconnectors.

3.3 FIELD QUALITY CONTROL

- A. Upon completion of installation of electrical switch disconnectors and after circuitry has been energized, demonstrate capability and compliance with requirements. Close all switches to check for proper energization of all loads. Where possible, correct malfunctioning units then retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

END OF SECTION 14

SECTION 15

LOW VOLTAGE CIRCUIT BREAKERS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions (General requirements), apply to work of this section.
- B. Basic electrical materials and methods, section 16050 applies to work of this section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services and tests necessary to complete and make ready for operation, circuit breakers as shown in accordance with Drawings and Specifications.

1.3 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in the manufacture of circuit breaker of the types and capacities required, whose products have been in satisfactory use in similar service for not less than 10 years.
- B. Standards Compliance: Comply with requirements of applicable local codes, IEC 60947 pertaining to circuit breakers.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's data for circuit breakers indicating the type and characteristics.

PART 2 - PRODUCTS

2.1 RECOMMENDED MANUFACTURER

Refer to list of recommended manufacturers.

2.2 AIR CIRCUIT BREAKERS

1. GENERAL

- A. Air break solid state type circuit-breakers motor operated type, (ACBs) unless otherwise indicated in the drawings.

2. CONSTRUCTION

A. GENERAL REQUIREMENTS

ACBs shall be metal-clad, cassette type with positively driven "ON/OFF" indication.

B. INTERCHANGE

Means shall be incorporated to prevent the wrong circuit-breaker being racked in at fixed position.

C. SECURITY

Means shall be provided to padlock the breaker in the service, isolated and test positions; and to close and independently padlock the shutters as specified in the schedules. It shall not be possible to withdraw or rack-in shall be prevented.

Robust padlocks or cylinder locks shall be provided to lock each circuit-breaker in one or other position during on-site testing and commissioning. This shall include locking the shutters closed when a circuit-breaker is racked out. Two sets of keys shall be provided for each padlock, together with a key cabinet and key schedule.

- D.** ACBs shall be fitted with the protection devices solid state type, instruments indicators and auxiliary control functions as specified in the schedules/drawings.

E. OPERATING MECHANISMS

ACBs shall be of the triple-pole type as specified in the schedules/drawings.

Where specified, operating mechanisms shall be the trip-free type and shall have a latching current equal to the short-circuit prospective value. The ACB shall be fitted with an instantaneous digital trip or making current release which operates when the ACB is closed onto a short-circuit. Anti-pumping devices shall be fitted to all operating mechanisms.

ACBs with a spring stored energy closing mechanism shall be used in an arrangement involving interlocking with other ACBs, the manual discharge of the spring closing mechanism shall be disabled by the interlocking system.

Facilities shall be provided to remove or blank off the integral mechanical "CLOSE" pushbutton where it could be used to override protection devices, lockout relays or remote operating signals.

Mechanisms which store energy shall be fitted with stored energy status indicators.

F. OPERATING FACILITIES

The ACB shall have facilities for isolation, withdrawal and test position operations with the ACB isolated. Carriage position switches shall be provided for connection into appropriate control circuits to permit electrical interlocks to be defeated when the ACB is in the isolated and (where applicable) test positions as specified in the schedules.

G. OPERATION CLEARANCE

Circuit-breakers shall be installed with full clearances for arc-chute vents and adequate side clearances for unimpeded operation and maintenance.

3. RATING

A. GENERAL REQUIREMENTS

The service performance characteristics shall be as specified in the schedules and drawings.

Ratings specified are the required on-site ratings. Written confirmation shall be provided to confirm that specified ratings will be obtainable under the conditions in which each circuit-breaker operates. Operating conditions shall include due allowance for ambient temperature, enclosure, physical situation, position and attitude of the ACB and the proximity of other devices on full load.

B. LABELLING

A label shall be provided, in a clearly visible position on the front of each circuit-breaker on which the service performance characteristics shall be displayed.

4. PROTECTION AND TRIPPING

A. TRIPPING

Tripping requirements shall be selected so as to ensure full selectivity between system levels by the tenderer. Tripping shall be of the solid state type with selectable characteristics and comply with IEC, standards.

All tripping units shall be provided with test facilities for use in commissioning and testing from the front of the switchgear.

B. TRIPPING CHARACTERISTICS

Details of tripping characteristics shall be provided for each type of ACB at time of tender. The details shall include manufacturer's full current discrimination tables showing over current and short-circuit discrimination and, additionally a full set of overlay transparency discrimination curves to enable discrimination settings to be checked.

All over current and short-circuit protective devices shall have separately adjustable time and current settings. Adjustments and settings shall be possible from the front of the ACB. The setting adjustment devices shall be behind a lockable cover plate, or similarly protected against unauthorized access.

Energy for protective devices shall be obtained from integral current transformers. Separate current transformers shall be of the accuracy class specified in the schedules and comply with IEC, standards, and of suitable ratio and rating for the operating conditions. If the circuit-breaker is de-rated because of high temperature then the current transformers shall be replaced with ones suitable for the higher operating temperatures. Protection current transformers shall not be de-rated.

Under voltage, trip and closing coils which shall incorporate adjustable time delay shall incorporate adjustable time delay shall be wired out to secondary isolating contacts in the same position on each breaker to ensure interchangeability of ACBs with the same service performance characteristics.

ACB tripping unit to be of adjustable current and time setting for L, S, I for all circuit breakers above and including 1000 A rating.

The tripping unit must provide earth fault protection.

C. COMMISSION LABEL

A label shall be provided, in a clearly visible position on the front of each circuit-breaker, on which the final commissioned release setting for that circuit-breaker shall be displayed.

5. AUXILIARY CONTACTS

- A. ACB auxiliary circuits shall be arranged to provide a wiping action on contacts during withdrawal and re-instatement of the ACB, to and from its isolated position
- B. On completion of the switchgear installation, each ACB shall be provided with auxiliary contacts available for future use for both the ACB contact operation and the isolation operation as specified in the schedules/drawings. Wiring to the switching contacts shall be ferruled and brought to a terminal block.
- C. All auxiliary contacts shall be mounted in accessible positions and away from possible electrical and mechanical danger.

6. SHUTTERS

- A. Where ACBs are isolated, safety shutters shall automatically cover exposed conductors.

- B. The shutters shall be able to be padlocked in the closed position, but shall be capable of being fixed open where tests require conductor contact.
- C. Shutter shall operate automatically by the movement of the circuit-breaker, preferably without using springs.
- D. Shutters shall be painted to IEC, DIN/VDE standards:

Additional Requirements	Lettering (White)	Color	Shutters
_____	"DANGER LIVE CABLES"	"Signal Red"	Incoming Circuit Shutters
_____	"BUSBARS	"Signal Red"	Busbar Circuit Shutters
With white arrows to indicate the section of switchgear with which the shuttered contacts are associated	"BUSBARS (on each)	"Signal Red"	Bus-Section Shutters
_____	_____	"Lemon"	Circuit Shutters

7. FINISHES

- A. Special treatments and finishes such as tropicalisation, anticorrosion finish and cold-climate treatment shall be applied where specified or where conditions make such treatment necessary.

8. TOOLS

- A. Loose equipment shall include test leads and a lifting and transporting device plus any other tools or equipment needed for routine maintenance.

9. TESTING

- A. ACBs shall be type tested by an independent approved testing authority and a complete Compliance Certificate, including short-circuit ratings, shall be provided for each type of circuit-breaker.
- B. In addition to the normal test requirements of IEC 60947, ACBs shall be type tested in enclosures similar to those in which they will be installed on site. Such tests shall include temperature rise tests.

- C. A complete set of manufacturer's on-site testing and calibration equipment shall be provided for commissioning and testing and for future fault diagnosis, testing and re-calibration of settings, trip units, control units and process controllers forming part of the installation.

2.3 MOULDED CASE CIRCUIT BREAKERS

1. GENERAL

A. DEFINITIONS

The definitions of terms and symbols used in this Specification are those used in IEC 60947.

B. STANDARDS

Moulded case circuit-breakers , (MCCBs) shall comply with IEC 60947: Part 2 plus any additional requirements of this Specification.

Moulded case circuit breakers should be equipped with solid state release of adjustable type for rating 400 Amp. And more and with thermal / magnetic release of adjustable type for rating less than 400 A.

C. GENERAL

Short-circuit capacities, impulse withstand voltages and insulation levels shall be suitable for the location of the circuit-breaker in the system, i.e. at service entrance level, distribution circuit level, load level or specially protected level.

MCCBs shall be selected to ensure full selective up to and including the prospective short-circuit, and earth fault currents for prospective earth fault currents the disconnection times shall not exceed 5s.

2. CONSTRUCTION

A. MANUFACTURE

MCCBs shall be manufactured with double insulation of the front face, insulating auxiliary components from the main power poles thereby allowing as far as reasonable the fitting of auxiliary units on site without full isolation of the unit.

B. CURRENT RATINGS

Rated currents, rated service short-circuit breaking capacities and trip release settings shall be as specified in schedules and on drawings.

Current ratings as specified in the schedules and drawings are for uninterrupted duty at 220/380V in the final installed location on site under full load operating conditions of the complete installation, i.e. taking account of heat produced by other devices and the ambient temperature, physical situation, enclosure, position and attitude of the

MCCB. The appropriate de-rating factors shall be applied to manufacturer's standard ratings when selecting MCCBs to meet the specified ratings.

MCCBs shall be suitable for operation in both the horizontal and vertical mounting position without detrimental effect on operation or rating.

C. TRIPPING CHARACTERISTICS

Details of tripping characteristics shall be provided for each type of MCCB. The details shall include manufacturer's full current selectivity tables showing overload and short-circuit selection and additionally, a full set of overlay transparency selecting curves to enable selective settings to be checked.

D. TEST CERTIFICATES

Complete certificates shall be provided for each type of MCCB, stating the service and ultimate short-circuit capacities.

E. CONTACTS

The contact arrangement of current-limiting MCCBs shall be such that the current-limiting contacts are in series with the main contacts and remain closed in normal operation, including time delayed over current tripping.

Contacts shall be arranged so that normal current is carried by low-resistance silver alloy or other non-welding material while arcing is handled by tungsten contacts.

Multi-set contact MCCB's shall be arranged using one set of contacts for thermal current and other for arc interruption.

F. TERMINALS

Terminals shall be sized to accommodate the size and type of cable of incoming and outgoing circuits as specified in the schedules or drawings. MCCBs shall be provided complete with terminal shields.

Terminals shall be arranged for direct connection to busbars, front or rear as required by the switchboard design.

All poles of multi-pole circuit-breakers shall be constructed so that contacts open, close and trip simultaneously. It shall not be possible for one or more poles to be closed while another remains open and vice-versa.

G. OPERATING MECHANISMS

Operating mechanisms shall be over-center, quick-make, quick-break type having operation in which speed of operation of the breaker is independent of the operator.

The handles shall be lockable in both open and closed positions.

Where motor operated MCCBs are specified in the schedules or drawings, the motors the clutches shall be as scheduled. Direct action operating handles shall be provided for local operation.

Where solenoid operated MCCBs are specified in the schedules or drawings, the operating voltage shall be as scheduled. Separate solenoids shall be provided for opening and closing operations. Built-in push buttons shall be provided for local operation.

Indication of the "ON", "OFF" and "TRIPPED" conditions shall be provided not only by the position of the handle but also by means of a colored band, or line which shall be visible when the circuit-breaker is on but not when it is off or tripped.

The "TRIPPED" condition shall be indicated by the handle assuming a mid-point position between "ON" and "OFF" It shall not be possible to manually place the handle in the tripped position.

Indication shall be provided to confirm that all main contacts have separated.

H. ENCLOSURES

Moulded case covers and non-interchangeable trip elements shall be permanently sealed at works to prevent tampering, but the trip elements may be changed/Adjusted and re-sealed on site by using suitable tools.

All internal components of MCCBs shall be replaceable on site. MCCBs

shall be certified as satisfying the leakage current testes called for in IEC 60947 with regards to safety isolation.

MCCBs used for motor starting shall satisfy the Type 2 coordination requirements called for in IEC 60947. The MCCB and the starter shall preferably be of the same manufacture, and in all cases shall be tested together and certified as satisfying the co-ordination requirements.

All MCCBs shall be of the same manufacture and those of like kind shall be of the same type. This requirement applies to loose or individually mounted MCCBs as well as to those incorporated within assemblies such as control panels, switchboards and distribution boards.

I. PROTECTION MECHANISMS

Each pole shall provide inverse time over current protection and adjustable high set instantaneous tripping. All poles shall trip simultaneously if one detects a fault.

Trip units above 250A shall be replaceable.

Tripping mechanisms shall be selective limiting type to obtain discrimination or by interconnection with other MCCB trip units. All adjustable trips shall be visible and adjustable from the front with the breaker in position. Adjustments to trip settings shall be made to all poles simultaneously by means of a common adjustment mechanism.

J. OPERATING FACILITIES

Facilities shall be provided for the use of a hand-held tester for on-site testing of all operational features.

Where specified in the schedules/drawings, earth leakage trips, shunt trips, undervoltage trips and remote operation shall be provided. These accessories shall all be factory assembled and tested.

3. AUXILIARY CONTACTS

- A. Auxiliary contacts shall be provided auxiliary contacts shall operate simultaneously with the main breaker contacts.

4. TESTING

- A. Testing shall be carried out in the manner prescribed in IEC 60947 plus any additional testing required on circuit-breakers for use in non-standard conditions.
- B. For MCCBs of 1250A rating and above, a set of manufacturer's plug-in setting/testing/diagnostic equipment shall be supplied for routine testing, setting and fault diagnosis. Unless otherwise stated, only one test set is required regardless of the number of MCCB's supplied.

5. GENERAL INFORMATION

- A. The following information shall be provided for each MCCB .
- Voltage and rated insulation voltage.
 - Rated current
 - Rated operational voltage and rated insulation voltage.
 - Number of poles
 - Rated service and ultimate short-circuit capacities.
 - Method of mounting
 - Method of connection
 - Protection against external influence
 - The I^2t tripping characteristic curves and the peak let-through currents at prospective fault levels,
 - Rated short time withstand current
 - Rated short-circuit making capacity

6. LABELLING

- A. On the front of each MCCB a visible label shall be fitted and described as follows:
Labelling shall be marked as follows:

- Rated current and trip setting (for MCCBs with multiple current ratings the maximum value shall be marked plus, without ambiguity, the value for which the MCCB has been adjusted),
- Rated voltage
- Manufacturer's name or trade mark
- Type designation, catalogue number or serial number
- Rated short-circuit capacity in amperes
- Reference ambient temperature.

A label shall be provided, in a clearly visible position on the front of each circuit-breaker, on which the final commissioned release setting for that circuit-breaker shall be displayed .

2.4 MINIATURE CIRCUIT BREAKERS

1. GENERAL

- A. Miniature circuit-breakers (MCB's) complying with IEC, 60947 shall be acceptable, however, all MCB's shall comply with the same standard and be from the same manufacturer's range. MCBs shall be rated for uninterrupted duty at 220/380V.
- B. MCBs shall have Type Tested. Manufacturer's tripping characteristics shall be provided for each type of MCB specified.
- C. Service short-circuit capacities shall be as specified in the switchboard details.
- D. The joule integral ($I^2 t$) energy withstand let-through shall be specified for each MCB.
- E. In multi-pole MCBs, including four-pole, all poles shall open, close and trip simultaneously unless otherwise indicated in the schedules.
- F. Miniature circuit breakers will be used in panel boards only in lieu of MCCB provided that, the full selective system and short circuit level indicated in the design drawing and schedules are achieved.

2. MECHANISMS

- A. Mechanisms shall be quick-make, quick-break, over-center type which are trip-free. The contact position shall be positively indicated by coloured bands and/or lettering to show whether the contacts are open or closed.

3. SECURITY

- A. MCBs shall be proved with effective means of locking in the "OFF" position.

4. CHARACTERISTICS OF CIRCUIT-BREAKERS

- A. MCB current ratings and instantaneous tripping characteristics shall be as specified in the Cable and Distribution Board Schedules
- B. The manufacturer's standard range shall include all MCB ratings, characteristics and auxiliaries specified in the schedule.

2.5 RESIDUAL CURRENT DEVICES (RCDS)

1. GENERAL REQUIREMENTS

- A. This section of the Specification covers residual current devices (RCDs) intended for protection of final circuits RCD's shall be installed on circuits as specified in the single line diagrams .
- B. RCD's shall comply with IEC, 60947 and with the requirements of the IEE Wiring Regulations. A residual current-operated circuit-breaker (RCCB) shall come within the scope of RCD as used in this Specification.
- C. RCD shall incorporating overcurrent and short circuit trips and used as circuit-breakers.
- D. Residual current shall be measured by a transformer which may be zero-sequence-connected or core balance type.
- E. RCD's shall have rated tripping currying currents as follows ;
 - 10 m Amp for wet areas.
 - 30 m Amp for general application
- F. RCD's shall operate in 0.4 seconds or less.
- G. RCD's 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. This requirement shall apply whether or not the RCD is the sole or main circuit breaker at that point in the system.
- H. Unless used as circuit-breakers RCD's shall be connected in series with the overload and short-circuit devices in the system.
- I. RCDs shall not be used as the sole means of protection against direct contact.
- J. Every RCD shall be provided with a test button and an engraved, clearly legible label stating "TEST FREQUENTLY"
- K. RCD's shall be suitable for loads with high crest factors and shall operate correctly irrespective of the harmonic or direct current content of the wave form.

- L. RCD's shall not trip out on loss of supply voltage.
- M. RCD's shall be provided with auxiliary contacts for operation and controls.
- O. RCD's shall be two poles for single phase circuits and four poles for three phases.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which circuit breakers are to be installed and notify the engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install circuit breakers as indicated, in accordance with manufacturer's written instructions, requirements of applicable Standards, and in accordance with recognized industry practices to ensure that installation complies with requirements and serves intended function.
- B. Coordinate, as necessary to interface installation of circuit breakers.
- C. Provide carriage for withdrawable circuit breaker.

3.3 FIELD QUALITY CONTROL

- A. Prior to energization of circuit breakers, test devices. Replace malfunctioning units with new units and then demonstrate compliance with requirements.

END OF SECTION 15

SECTION 16

LOW VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions (General requirements), apply to work of this section.
- B. Basic electrical materials and methods, section 16050 applies to work of this section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services and tests necessary to complete and make ready for operation, all switchgears in accordance with drawings and specifications.

1.3 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in the manufacture of switchgears of the types, and capacities required, whose products have been in satisfactory use in similar service for not less than 10 years.
- B. Standards Compliance: Comply with requirements of applicable local codes, IEC 60439, IEC 60974 pertaining to low voltage switchgear.

1.4 SUBMITTALS

- A. **Product Data:** Submit manufacturer's data for L.V switchgears, including size, enclosures, and electrical ratings and characteristics.
- B. **Shop Drawings :** submit dimensional layout of L.V switchgears on architectural background drawings.

- C. **Selectivity Study**

Submit to the Engineer a relay and C.B. selectivity study based on a fully selective system.

The Current-time characteristics must be plotted on a log-log papers showing that the choice of the C.B. settings are correct for full selective system.

- D. **Short circuit and Voltage Drop Calculation**

Submit a comprehensive short circuit study as well as voltage drop calculation based on the actual impedance values of the electrical components such as supply short circuit level at the 11 KV (shall not be less than 500 MVA), transformer per unit impedance, bus bars and cable impedances ... etc.

E. Load Balance

Submit a detailed load list verifying the load balance across the phases.

PART 2 - PRODUCTS

2.1 RECOMMENDED MANUFACTURER

Refer to list of recommended manufacturers.

2.2 GENERAL

- A. The switchgears shall be 1000 V class, three phase, 50HZ completely wired and type tested at the factory, ready for installation on the site. Sectionalizing shall be accomplished and bracing provided for access of the equipment into the building.
- B. Switchgears shall be designed and manufactured to comply with IEC - 60439, and IEC 60947.
- C. The Electrical installation has been designed to give load balance across the phases as far as possible but it is the contractor's responsibility to maintain or improve the balance when making connections to bars etc.
- D. When the final commissioning is to be completed the contractor shall allow in his tender for checking loads and altering connections in order to achieve as even a balance over the phases.

2.3 CONSTRUCTION

- A. The switchgears shall be of the type tested totally enclosed, front and rear. accessible, indoor type, of size, rating and arrangement as indicated on the Drawings. The complete assembly shall be floor mounted, free standing, with matching cases, to form a continuous integral structure.
- B. Switchgears shall consist of number of compartmented formed and welded sheet enclosures required to mount circuit- breakers transformers and other specified equipment as shown on the Drawings.
- C. Switchgears shall be completely enclosed with hinged front covers and removable steel plates of not less than 2.0 mm gauge on sides, top and rear.
- D. All fastenings between structural members shall be bolted, not welded, to provide flexibility during installation.
- E. The arrangement shall permit the busbars and/or cables to enter from the top or bottom of the enclosures as shown on the Drawings and connect at their respective terminals without interference.

- F A modular arrangement shall be used to permit interchanging differently sized device cover plates without additional drilling of structure.
- G. Structures and busses shall be arranged to permit future sections to be added. A suitable cover plate shall be provided for temporary protection.
- H. Switchgears shall be of insulation class IP 42 form 2 b according to IEC 60529.
- I A spare position shall be fully equipped cell with a circuit-breaker.
- J Suitable arrangement and equipment shall be provided for extracting and unloading the circuit-breakers from their cells.
- K A special trolley shall be supplied together with the switchgear for removal or installation of the air-circuit breakers from their compartment for maintenance or repair.
- L An earth bus extending the entire length of the assembly shall be provided. The bus shall be sized in accordance with IEC 60439.
- M The switchgear shall be sanded and rust inhibited after fabrication, electro - static painted on both inside and outside surfaces. .
- N The Switchgear shall be provided with inlet air filtration .

2.4 BUS BARS

- A. All copper bus bars, switching devices and connections shall be of sufficient sizes and material at contact to limit the temperature rise to be in accordance with IEC 60439-1.
- B. All bus bars and connections shall be accessible for inspection and maintenance purposes.
- C. Bus bars are to be of high conductivity copper and rigidly supported to withstand the mechanical stress of a rated short- time withstand current in accordance with IEC recommendation No.60439-1.
- D. All main horizontal and vertical bus bars shall be insulated with high quality electrical grade epoxy insulation.
- E. Bus bars shall be clearly marked with their respective phase colors and shall be furnished for future extensions.
- F. The main set of bus bars shall be housed in segregated chamber. Bus bar top covers shall be capable of supporting a man weight without deflection.
- G. Incoming and outgoing supplies to switchgears shall be either busways or cables as indicated on drawings, the enclosure sheet metal around the conductors or busways shall be non-ferrous type.
- H. A full length ground copper bus shall be provided. The ground bus shall be bounded to the metal enclosure of each compartment and to metering and

relaying, transformers secondary windings. Lugs shall be provided one at each end of the ground bus and one in each cubicle for the user's copper ground cables.

- I. The cross sectional area of neutral and earth bus bars shall be equal to the associated phase bars.
- J. Access to bus bars and bus bar connections shall be possible only after the removal of covers secured by bolts or studs. Such covers shall be identified externally by engraved laminated labels bearing the inscription "BUSBARS DANGER 380 VOLTS" in 30mm high black lettering on a yellow background.
- K. Connections from main and dropper busbars to the supply side of functional units shall be by means of dedicated conductors. Conductors installed on a loop in principle shall not be acceptable.
- L. All neutral supply/load connections shall be made via the enclosure containing the associated functional unit. Common neutral terminals shall not be acceptable.
- M. No diversity shall be used in busbar dropper sizing.

2.5 AUXILIARY WIRING

- A. All non-screened auxiliary wiring, except that which is required to be screened, shall be carried out on 450/750V grade insulated, multi-stranded flexible conductors.
- B. The minimum conductor size shall be 1.5mm².
- C. All auxiliary wiring shall be identified at both ends with numbered and resistor color coded ferrules. These numbers shall be shown on the control schematic wiring diagram.
- D. All auxiliary wiring shall be contained within cabling trunking and totally segregated from power wiring as far as practicable. Wiring of circuits at different voltage categories, e.g. L.V. and ELV, shall be segregated. Joints will not be permitted on wiring between devices.
- E. Cable trunking shall be of the ventilated type with clip-on covers and purpose made junctions and accessories. Cables shall not occupy more than 40% of the trunking cross-sectional area.
- F. Wiring not contained within trunking shall be strapped in looms with removable straps and held in place by suitable cleats. Looms shall not exceed more than 25 wires. Self-adhesive straps shall not be acceptable.
- G. All wiring connections from trunking and looms to devices shall be run in straight lines, horizontally and vertically, and be neatly dressed.
- H. Wiring to door mounted devices shall be flexible and provided with a large enough loop to clear the edge of the opening. Protection against abrasion shall be provided by means of flexible conduit or spiral wrapping securely fixed at each end.

- I. Where wiring passes through partitions it shall be protected against abrasion by thermoplastic grommets and spiral wrapping.
- J. Interconnections between functional units shall be contained within a separate cabling chamber or trunking. All cables shall terminate on the functional unit terminals within the cubicle.

2.6 LABELS

- A. All enclosures containing functional units shall be clearly labelled with a circuit, unit reference and current rating.
- B. All labels shall be of the engraved type made from suitable multi-layer laminate and shall be fixed with zinc plated cheese head instrument screws. No other type of label will be acceptable.
- C. Every functional unit shall be labelled separately from all others. External labels shall have letters not less than 5mm in height and internal labels not less than 3mm. The letters shall be black in color on a white background.
- D. All covers/doors not fitted with interlocked switched disconnectors enclosing unshrouded live equipment shall be fitted with warning labels inscribed "DANGER 380V ISOLATE BEFORE OPENING".
- E. Warning labels shall have black letters on a bright yellow background. Wherever possible, letters shall be not less than 30mm in height. On small covers and doors letters of 20mm or 10mm in height shall be used.
- F. Cable boxes shall be clearly labelled both externally and internally with the circuit and functional device number.
- G. All terminal blocks shall be labelled relative to the respective functional unit.
- H. Every control and metering device, selector switch, pushbutton and indicator light shall be clearly labelled to indicate its purpose.
- I. Main identification labels shall be provided on the assembly together with a rating plate.
- J. Fixed and withdrawable portions of equipment including fixed and plug-in devices shall be labelled with withdrawable portions cross-referenced to their fixed part.
- K. Proposed engraving details shall be submitted for comment prior to engraving.

2.7 EARTHING

- A. Each assembly shall be provided with a continuous copper earth bar running the whole length sized for the prospective short-circuit current.
- B. Discrete terminals shall be provided for connection to all the protective conductors. Each individual section of the assembly shall be separately bonded to the main earth bar.

2.8 COMPONENTS

- A. All components shall be installed in accordance with the instructions of their manufacturers. This requirement does not negate the requirement for type and routine testing as specified elsewhere in this Specification.
- B. Adjusting and resetting devices shall be easily accessible.
- C. All components shall be installed and wired such that their function is not impaired by interaction such as heat, arcs, vibration, and fields of energy present in normal operation.
- D. Barriers for manual switching devices shall be designed such that arcs caused by switching under normal operation or the interruption or making of a fault current shall not present a danger to the operator.
- E. All removable and withdrawable components shall be installed and designed such that they can be safely disconnected or connected to supply circuits while the associated conductors are live.
- F. All spare contacts on relays, contactors, and the like shall be wired to easily accessible terminal blocks, suitably positioned for future external wiring.
- G. Assemblies shall be provided with a spare set of fuses mounted on polyethylene coated spring clips adjacent to the fuse chart on the doors of a separate cubicle. A total of 20% of each size of fuse shall be provided with a minimum 4 of each size. When commissioning is complete the panel shall be handed over with this complete set of spare fused. A fully detailed fuse chart shall be provided in the same cubicle as the fuses.

2.9 SELECTOR SWITCHES/PUSH-BUTTONS/INDICATOR LAMPS

- A. The manufacturer's range shall include fully interchangeable contact blocks and lamp holder blocks which can be fitted to all actuators including switches and push-buttons.
- B. Selector switches shall be of the rotary type, with lever or key operated actuators
- C. Pushbuttons shall be of the flush type.
- D. Pushbuttons used for emergency stop purposes shall be of the mushroom head type, with a twist to release action or key reset.
- E. Contact blocks shall have double break silver plated contacts, in 'NO' or 'NC' configuration rated at not less than 5A resistive at 220V 50HZ.
- F. Indicating lamps shall be of the high quality LED flush type 22mm diameter with removable colored lenses, allowing lamps to be changed from the front.
- G. Indicating lamps on control circuits shall be equipped with completely sealed dual wound safety isolating transformers and in-built test relay.

2.10 WIRING TERMINALS

- A. Cable terminations and space for terminations shall be suitable for the sizes of cable called for in the design.
- B. Terminal blocks shall be made of thermosetting melamine or polyamide material with a low tracking index and good flame resistance, tested to withstand a temperature rise of 90°C above ambient temperature. Provision shall be made for permanent labels to be applied to each terminal for identification purposes.
- C. All terminals for control wiring shall have provision for plug-in test spills and in addition be fitted with isolating links. Current carrying parts shall be made of tinned brass or copper.
- D. Completely shrouded terminals of the tunnel type shall be used for cables up to 10mm². The screw clamp connection shall be vibration proof, self-locking and suitable for clamping two conductors.
- E. Stranded cables up to 10mm² shall be terminated in copper or copper alloy ferrule shall retain all strands of the cable.
- F. Terminals for cables in excess of 10mm² shall be of the double connection type with bolted studs for the connection of cable lugs. The terminal and stud size shall be adequate for the current carried and the size of cable. Suitable insulating partitions and protective covers shall be provided.
- G. All auxiliary wiring except screened cables shall be connected to incoming/outgoing cables Via insulated terminal blocks, screw/screw type, clipped onto DIN rails. There shall be sufficient space on the DIN rail for future terminal blocks of not less than 10% or 5 No. whichever is the greater.
- H. Wires shall enter terminals singly.
- I. Plugs and fixed sockets for the application shall be provided for the termination of screened cables.
- J. All terminations shall be mounted at least 0.2m above the base of floor mounted assemblies .
- K. All load terminals shall be suitable for the types and sizes of cables as specified in the schedules and drawings.

2.11 WORKS TESTS

- A. All assemblies shall be tested in accordance with the requirements of IEC 60439 standards Part 1, plus requirements of associated standards.

- B. TYPE TESTED ASSEMBLIES (TTA)

Where TTAs are specified, certification shall be provided for all type and routine tests to IEC 60439 standards.

C. PARTIALLY TYPE TESTED ASSEMBLIES

Where PTTAs are specified, compliance with the test requirements of IEC 60439, shall be either by type testing or by extrapolation from type tested assemblies or individual parts of similar, representative construction. Verification of the Type Testing Certification or the appropriate extrapolation calculations shall be provided. Certificates shall also be provided for routine tests.

- D. Calculation from first principles for temperature rise and short-circuit strength will not be acceptable.
- E. Verification of the short-circuit withstand strength is not required for assemblies having a rated PSSC not exceeding 10KA or those protected by current limiting devices with a cut-off current not exceeding 15KA.
- F. Verification of the short-circuit withstand strength is not required for auxiliary circuits connected to transformers whose:
- (1) rated power does not exceed 10KVA for a rated secondary voltage of not less than 110V.
 - or
 - (2) rated power does not exceed 1.6KVA with a rated secondary voltage of less than 110V, and whose relative short-circuit voltage is not less than 4%.
- G. Works tests shall include inspection of all wiring and a complete electrical functioning test.
- H. Protection relays shall be tested by primary current injection with currents equal to overload, short-circuit and earth fault conditions.
- I. Works tests shall be done in the presence of the engineer.

2.12 FIELD TESTING

A. ASSEMBLIES

All assemblies shall be subjected to the routine tests as defined in IEC, 60439 standards. after installation on site. Test Certificates shall be provided.

B. FUNCTIONAL UNITS

All functional units shall be checked for correct mechanical operation.

C. PROTECTION CIRCUITS

All protection circuits in with relays used shall be tested for correct operation by secondary injection of test currents. This shall be carried out at currents equivalent to overload, short-circuit and earth fault conditions.

D. CURRENT TRANSFORMERS

Protection circuits using current transformer (CT) operated relays shall be tested by primary injection of current to prove the transformer ratio.

2.13 COMMISSIONING

- A. Following the satisfactory conclusion of inspections and tests on completed sections of the Works, each switchgear assembly shall be duly commissioned and left in full working order. The term "Commissioning" shall be deemed to include:
 - (1) The energizing of functional device circuits and equipment which have previously been inspected, tested, found to be satisfactory and capable of being energized with complete safety.
 - (2) The starting up of all electrically powered plant and equipment, including that supplied and installed under other contracts, and as specified in the schedules.
 - (3) The verification of the performance of each switchgear assembly relative to all such plant and equipment by the carrying out, where required, of further tests and the making of all necessary adjustments so as to obtain optimum performance.
 - (4) The proving of all interlock operations in all possible combinations and the operation of all control systems, metering and indications to meet the performance requirements specified.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which switchgears are to be installed, and notify engineer in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install switchgears as indicated, in accordance with manufacturer's written instructions, requirements of applicable Standards, and in accordance with recognized industry practices to ensure that installation complies with requirements and serves intended function.
- B. Coordinate as necessary to interface installation of switchgears with other works.
- C. Tighten connectors and terminals, including screws and bolts and equipment grounding connections, in accordance with equipment manufacturer's published torque tightening values for equipment connectors.
- D. Fasten enclosures firmly to walls and structural surfaces, ensuring that they are permanently and mechanically anchored. Provide all angle units and accessories for proper mounting.

- E. Provide properly wired electrical connections for switchgears within enclosures.
- F. Double lugging is not permitted.
- G. Fill out switchgears circuit directory card upon completion of installation work.
- H. Provide equipment earthing connections sufficiently tight to assure a permanent and effective ground for panelboards.
- I. Provide 6.0 mm minimum thick x100 cm wide insulation mat in front of low voltage switchgear and near of freestanding equipment and extend 50 cm beyond ends.

3.3 FIELD QUALITY CONTROL

- A. Upon completion of installation of switchgear and after circuiting has been energized, demonstrate capability and compliance of switchgear with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units and retest.
- B. Prior to energization of switchgears circuitry, check all accessible connections to manufacturer's tightening torque specifications.
- C. Prior to energization of switchgears, check with earthing resistance tester phase-to-phase and phase-to-ground insulation resistance levels to ensure requirements are fulfilled.
- D. Prior to energization, check switchgears for electrical continuity of circuits, and for short circuits.
- E. Adjust operating mechanisms for free mechanical movement.
- F. After energization, check phase balancing and adjust accordingly.
- G. Touch-up scratched or marred surfaces to match original finishes.
- H. The system supplier is responsible to provide all required switches, auxiliary contacts, relays, wiring, terminal blocks transducers to provide signaling and metering information for the building & energy management system (BEMS) to accept START/STOP, open/close, set point from it.

END OF SECTION 16

SECTION 17
INSTRUMENTS AND METERING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions (General requirements), apply to work of this section.
- B. Basic electrical materials and methods, section 16050 applies to work of this section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services and tests necessary to complete and make ready for operation instrument and metering as shown in accordance with Drawings and Specifications.

1.3 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in the manufacture of instrument and metering of the types and capacities required, whose products have been in satisfactory use in similar service for not less than 10 years.
- B. Standards Compliance: Comply with requirements of applicable local codes, IEC 60051. Standards pertaining to instrument and metering.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's data for instrument and metering.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

All electrical indicating instruments shall comply with IEC 60051 and shall be digital type.

2.2 INSTRUMENTS

A. GENERAL REQUIREMENTS

- 1. All electrical indicating instruments shall be the product of a single manufacturer.
- 2. All ammeters and voltmeters shall be digital type.
- 3. All instruments shall be flush mounted.

B. COMMON SPECIFICATIONS

- 1. STANDARD IEC 60051

2. ADMISSIBLE OVER LOADS

- a. Voltage :
 - 1.2 rated voltage continuously.
 - 2 rated voltage for 2 seconds.
- b. Current :
 - 2 In continuously.
 - 10 In for 10 seconds.
 - 40 In for 2 seconds.

3. DIELECTRIC STRENGTH : 2 KV. r.m.s. for 1 min.

4. OPERATING TEMPERATURE : - 10°C to + 60 °C.

5. DIGITAL PANEL METERS

Consists of :

- a. 3 1/2 DIGIT SERIES Display for Ammeters and 3 1/2 DIGIT for Ammeters and Frequency meters.

- b. ANALOG SECTION :

The conversion between the magnitude to be measured and the input to the digital section made from high accuracy components.

- c. DIGITAL SECTION :

An analog/digital converter is used with dual slope integration and automatic zero correction and shall have thermal stability from 0 to 60 °C and Linearity error is under 0.05%.

- d. DIMENSIONS

For all shall be (96 x 48 mm).

C. AMMETER AND VOLTMETER SWITCHES

- 1. On 3-phase, 5-wire system, ammeter switches shall have four operating positions, marked 'R', 'Y', 'B' and 'N', and an 'OFF' position, and shall enable the single ammeter to read, in sequence, the currents in each of the three phases and the neutral wire, On 3-wire systems ammeter switches shall have three operating positions marked 'R', 'Y' and 'B' and an 'OFF' position. Ammeter switches shall be connected so that the associated current transformers are short-circuited when they are not connected to the ammeter.
- 2. On 3-phase, 5-wire systems, voltmeter switches shall have six operating positions, marked 'R-Y', 'Y-B', 'B-R', 'R-N', 'Y-N' 'B-N', and an '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. On 3-wire systems, voltmeter switches shall have three operating positions marked 'R-Y', 'Y-B' and 'B-R' and an 'OFF' position.

3. Voltmeter switches shall have 'break-before-make- contacts.

2.3 CURRENT TRANSFORMERS (CTS)

A. GENERAL REQUIREMENTS

1. All CTs shall have an Accuracy Class Designation according to the following table:
 - Tariff metering
Accuracy Class Designation 0.5
 - Non-tariff metering
Accuracy Class Designation 1.0
 - Switchgear indicating instruments
Accuracy Class Designation 1.0
 - Motor starter ammeters
Accuracy Class Designation 3.0
 - Protection (overcurrent, UEF)
Accuracy Class Designation 10p
 - Protection (UEF)
Accuracy Class Designation x
2. Unless otherwise specified in the schedules or drawings, the CTs are required for use under service conditions not more onerous than those set out in IEC, standards.
3. CTS shall be designed either for measurement or for protection and shall not be used in a dual-purpose role serving both instruments and protective gear.
4. Unless otherwise specified, all CTs shall have 5A secondary windings.
5. So far as it is practicable, all CTs shall be of the ring type. Wound primary CTs will only be accepted when the rated primary current is so low as to make the ring type impracticable.
6. One side of the secondary of each CT shall be connected to earth at one point via a bolted removable link.
7. For metering circuits, either, a proprietary front of panel CT test block or special "shorting" terminals within the panel shall be provided for test purposes.
8. All CTs whether of the ring type or the wound primary type, for use at voltages exceeding 1000V shall be epoxy resin encapsulated.

Where dual-ratio CTs are specified, they shall be provided with two separate secondary windings capable of being connected in series or in parallel to give the required ratio.

9. All CTs shall be provided with a rating plate bearing the information as stated in IEC, DIN/VDE standards. All CTs shall be installed in accessible location. The secondary connections shall be brought out by means of insulated leads, and made off on a suitable terminal block-mounted in a readily accessible position.
Magnetization curves and/or type Test Certificates shall be provided for all CTs associated with protection devices.
10. Every CT shall have a rated burden at least 50% greater than the total burden of the instruments, relays, and/or other apparatus which it is to serve.

2.4 VOLTAGE TRANSFORMERS

A. GENERAL REQUIREMENTS

1. Voltage transformers shall be of the type, rating, and voltage ratio specified in the schedules or drawings.
2. All voltage transformers shall have an Accuracy Class Designation according to the following table:

-	Metering	:	Accuracy Class Designation 1.0
-	Switchgear indicating instruments:	:	Accuracy Class Designation 1.0
-	Motor starter voltmeters	:	Accuracy Class Designation 3.0
-	Protection	:	Accuracy Class Designation 3p
3. Unless other specified in the schedules or drawings, the voltage transformers are required for use under service conditions not more than those set out in IEC, standards.
4. Voltage transformers designed for a primary voltage not exceeding 4000V shall be the air insulated type, with the windings encapsulated in epoxy resin or other suitable synthetic material.
5. Unless otherwise specified, all voltage transformers shall be designed for a secondary output voltage of 110V.
6. Each voltage transformer shall have a rated burden at least 50% greater than the total burden of the apparatus or instruments which it is to serve.
7. The insulation resistance of each voltage transformer shall be indelibly marked on the shipping/dispatch label.

2.5 DIGITAL MULTI – METER (DMM)

A. GENERAL

1. DMM is an instrument for measuring and metering electrical values for three phase, low voltage balanced or unbalanced electrical networks.

2. DMM will has a front panel keys and LCD displays all the parameters and use the functions provided to measure electrical values and measure energy consumption.

B. MEASUREMENT :-

1. Instantaneous and maximum current over a programmable period (8 to 8 minutes).
2. Phase to neutral and phase to phase voltage.
3. Frequency (HZ).
4. Instantaneous and maximum active power (P) over a programmable period (8 to 30 min.), reactive power (S).
5. Power factor (PF).

C. ENERGY METERING

1. Active KWH.
2. Reactive KV arch.

- D. DMM will be provided with link protocol for using with DEMS.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which instrument and metering are to be installed and notify in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install instrument and metering as indicated, in accordance with manufacturer's written instructions, requirements of applicable Standards, and in accordance with recognized industry practices to ensure that installation complies with requirements and serves intended function.
- B. Coordinate, as necessary to interface installation of instrument and metering.

3.3 FIELD QUALITY CONTROL

- A. Prior to energization of instrument and metering devices test devices for intended function Replace malfunctioning units with new units, and then demonstrate compliance with requirements.

END OF SECTION 17

SECTION 18
DISTRIBUTION BOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions (General requirements), apply to work of this section.
- B. Basic electrical materials and methods, section 16050 applies to work of this section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services and tests necessary to complete and make ready for operation, all distribution boards in accordance with Drawings and Specifications.

1.3 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in the manufacture of distribution boards of the types and capacities required, whose products have been in satisfactory use in similar service for not less than 10 years.
- B. Standards Compliance: Comply with requirements of applicable local codes, IEC 60439, IEC 60947 pertaining to distribution boards.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's data for distribution boards including size, enclosures, and electrical ratings and characteristics.
- B. Shop Drawings: Submit dimensional layouts on architectural background drawings.
- C. Selectivity Study

Submit to the Engineer a relay and C.B. selectivity study.

The Current-time characteristics must be plotted on a log-log papers showing that the choice of the C.B. settings are correct for full selective system..
- D. Short circuit and voltage drop calculation

Submit a comprehensive short circuit study as well as voltage drop calculation based on the actual impedance values of the electrical components such as supply short circuit level at the 11 KV (shall not be less than 500 MVA), transformer per unit impedance, bus bars and cables impedances.....etc.
- E. Load balance

submit a detailed load list verifying the load balance across the phased of each board.

PART 2 - PRODUCTS

2.1 RECOMMENDED MANUFACTURER

Refer to list of recommended manufacturers.

2.2 GENERAL REQUIREMENTS

- A. Distribution boards shall be type tested and shall comply fully with the requirements of IEC 60947, standards.
- B. All interior components shall be mounted on a rigid fabricated chassis capable of being removed and/or reversed for ease of wiring.
- C. Distribution boards shall be provided with a suitable earth bar and neutral bar, with adequate provision for the connection of a circuit protective conductor for each outgoing way.
- D. Terminals for the neutral conductor shall allow the individual connection of conductors having a current carrying capacity equal to the full current carrying capacity of the phase conductor.
- E. When the means of isolating the distribution board from the incoming supply is not to be mounted immediately adjacent to the board, means shall be provided in the distribution board to indicate whether or not the supply is "ON".
- F. Unless otherwise specified on the schedules or drawings, distribution board cases shall be fabricated from heavily rust-proofed heavy gauge sheet steel and be of all-welded construction. They shall be adequately braced or stiffened, by folding or otherwise, to form a completely rigid enclosure. Exterior corners and edges shall be rounded so as to give a smooth overall appearance.
- G. Distribution boards shall have a side-hung hinged front cover, attached by means of lift-off hinges, and fitted with cylinder type locking handles. Covers shall be braced or folded in such a manner as to prevent distortion or whip, and shall be fitted with dust-proofing gaskets or edge seals.
- H. Distribution board cases shall provide a degree of protection IP 42.
- I. Distribution board cases shall be of such dimensions that adequate space is available for manoeuvring and connecting the incoming and outgoing cables.
- J. Distribution boards shall be arranged for top or bottom or top and bottom entry according to the requirements specified on the drawings or in the schedules.

- K. Distribution boards shall be provided with detachable end plates as specified in the schedules or drawings.
- L. Each distribution board shall be provided with a durable circuit chart fixed to the inside of the cover or immediately adjacent and bearing typewritten details, in plain language, of the circuits supplied by each of the ways. The chart shall be on heavy weight paper or thin card, and shall be protected by means of a rigid transparent plastic cover, it shall be mounted in such a way that it can easily be removed for correction or alteration, then replaced. The size of the chart shall be such that there is adequate space of recording all of the required information and, in any case, shall not be less than A5 (210 mm x 148 mm).
- M. Each way in the distribution board shall be clearly numbered to correspond with the numbering on the circuit chart.
- N. Each distribution board shall be provided with an engraved plastic label on the outside of the front cover, bearing the designation of the board and its reference number, if any, as given on the drawings or in the schedules. The label shall be fixed in position by chromium-plated set screws. Each such label shall be not less in size than 100 mm x 30 mm, and shall bear the required inscription in white on a black background, using letters and/or digits not less than 5 mm high.

2.3 WORKS TESTS

- A. All assemblies shall be tested in accordance with the requirements of IEC 60439 standard Part 1, plus requirements of associated standards.
- B. Works tests shall include inspection of all wiring and a complete electrical functioning test.
- C. Protection relays shall be tested by primary current injection with currents equal to overload, short-circuit and earth fault conditions.
- D. Works tests shall be done in the presence of the engineer.

2.4 FIELD TESTING

A. ASSEMBLES

All assemblies shall be subjected to the routine tests as defined in IEC, standards. after installation on site. Test Certificates shall be provided.

B. FUNCTIONAL UNITS

All functional units shall be checked for correct mechanical operation.

C. PROTECTION CIRCUITS

All protection circuits with in relays used shall be tested for correct operation by secondary injection of test currents. This shall be carried out at currents equivalent to overload, short-circuit and earth fault conditions.

D. CURRENT TRANSFORMERS

Where specified in the schedules, protection circuits using current transformer (CT) operated relays shall be tested by primary injection of current to prove the transformer ratio.

2.5 COMMISSIONING

- A. Following the satisfactory conclusion of inspections and tests on completed sections of the Works, each switchgear assembly shall be duly commissioned and left in full working order. The term "Commissioning" shall be deemed to include:
- (i) The energizing of functional device circuits and equipment which have previously been inspected, tested, found to be satisfactory and capable of being energized with complete safety.
 - (ii) The starting up of all electrically powered plant and equipment, including that supplied and installed under other contracts, and as specified in the schedules.
 - (iii) The verification of the performance of each distribution board relative to all such plant and equipment by the carrying out, where required, of further tests and the making of all necessary adjustments so as to obtain optimum performance.
 - (iv) The proving of all interlock operations in all possible combinations and the operation of all control systems, metering and indications to meet the performance requirements specified.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which distribution boards and enclosures are to be installed, and notify Engineer in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install distribution boards as indicated, in accordance with manufacturer's written instructions, requirements of applicable Standards, and in accordance with recognized industry practices to ensure that installation complies with requirements and serves intended function.
- B. Coordinate as necessary to interface installation of distribution boards with other works.
- C. Tighten connectors and terminals, including screws and bolts and equipment earthing connections, in accordance with equipment manufacturer's published torque tightening values for equipment connectors.

- D. Fasten enclosures firmly to walls and structural surfaces, ensuring that they are permanently and mechanically anchored. Provide all angle units and accessories for proper mounting.
- E. Provide properly wired electrical connections for distribution boards within enclosures.
- F. Double lugging is not permitted.
- G. Fill out distribution boards circuit directory card upon completion of installation work.
- H. Provide equipment earthing connections sufficiently tight to assure a permanent and effective ground for distribution boards.

3.3 FIELD QUALITY CONTROL

- A. Upon completion of installation of distribution boards and after circuiting has been energized, demonstrate capability and compliance of panelboard with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units and retest.
- B. Prior to energization of electrical circuitry, check all accessible connections to manufacturer's tightening torque specifications.
- C. Prior to energization of distribution boards, check with ground resistance tester phase-to-phase and phase-to-ground insulation resistance levels to ensure requirements are fulfilled.
- D. Prior to energization, check distribution boards for electrical continuity of circuits, and for short circuits.
- E. Adjust operating mechanisms for free mechanical movement.
- F. After energization, check phase balancing and adjust accordingly.
- G. Touch-up scratched or marred surfaces to match original finishes.

END OF SECTION 18

SECTION 19

BUSBAR TRUNKING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions (General requirements), apply to work of this section.
- B. Basic electrical materials and methods, section 16050 applies to work of this section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner, all busbar trunking in accordance with Drawings and Specifications.

1.3 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in the manufacture of busbar trunking of the types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Standards Compliance: Comply with requirements of applicable local codes, DIN/VDE, IEC and BS. Standards pertaining to busbar trunking. Provide busbar trunking products and components which have been listed and labeled.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's data for busbar trunking and associated accessories.
- B. Shop Drawings: Submit dimensions layout drawings on architectural backgrounds of busbar trunking including, but not limited to, offsets and connections. Show accurately scaled busbar trunking with locations of supports and fittings, including fire-stops and weather seals. Indicate relationship of busbar trunking to other associated equipment and services.

PART 2 - PRODUCTS

2.1 BUSBAR TRUNKING

A. GENERAL

- 1. The busbar trunking plug in type shall be designed and constructed for use on a 380 V three phase four conductors [L1, L2, L3 + N] + E by housing] 50 Hz and having a source fault level of 65 KA 380 V for 1.0 second

2. The busbar trunking shall be of the totally enclosed sandwiched insulated type provided with busbars and with suitable tap-off positions as specified.
3. The ratings and numbers of busbars and lengths of trunking with details of tap-off points and equipment shall be as detailed in the Specification, schedules and drawings.
4. The moulded bus bar insulation and insulating supports will be made from insulation possessing flame retardant and self-extinguishing, die-electric and non-hygroscopic properties.
5. The bus shall carry its rated current continuously, without exceeding the temperature rise of 55 °C over an outside ambient of 45 °C.
6. The joints shall be of single bolt pressure design providing optimum electrical contact and mechanical strength.

B. BUSBARS

1. Busbars shall be generally as specified in IEC 60439.
2. The busbars shall be of rectangular section tinned hard drawn high conductivity copper.
3. Each busbar except the earth shall be totally enclosed in insulating material. Insulated and anti-tracking supports for the busbar shall be provided at regular spaced intervals of 300/600 mm. The supports shall be suitable for use of the busbar trunking in any position. In vertical positions the supports shall be capable of holding the vertical thrust of the busbars.
4. Jointing of the busbars shall be in accordance with the recommendations of the manufacturer, using purpose-made links throughout.
5. Where straight length of busbar trunking are installed in excess of 40 meters expansion joints shall be fitted in the busbar run.
6. Phase bus bars will be completely enclosed with molded or extruded insulation, except where provisions will be made for splicing adjacent sections together.
7. The joints for splicing adjacent sections together will be silver plated and enclosed by either moulded insulation bolts or approved taped insulation system.
8. The metal housing surfaces will be chemically cleaned and treated to provide a bond between the primer light gray paint and the metal surface paint film.

9. The exterior surfaces will be cleaned and sprayed with a finishing coat of paint before assembly of the equipment. The color of metal enclosed bus will be manufacturer's standard.
10. After assembly, all conductor joints shall be accessible by the removal of covers in the enclosure. Such covers shall be weather-proof by neoprene gaskets or other suitable means.
11. The preliminary layout will be furnished as a part of the material requisition. And the complete installation shall be coordinated throughout and shall consist of standard sections and special sections and fittings provided to suit the installation. And all material and installation shall comply with the applicable standards.

C. TRUNKING

1. The busbars shall be enclosed in metal trunking which shall be mechanically and electrically continuous, and the metal thickness proposed for all trunking, accessories and connectors shall be shown on the Manufacturer's Drawings.
2. The trunking shall be of the ventilated totally enclosed type to provided a degree of protection not less than IP 43 as per IEC standard.
3. All non-current- carrying metal associated with trunking for use in enclosed buildings shall be finished in accordance with IEC standard.
4. The busbar trunking shall be designed and constructed suitable for mounting in horizontal flat or edgewise position and in the vertical plane. Fixing points shall be at any position in the run, with unsupported spans not greater than 3 meters.
5. Fire resisting barriers shall be fitted in trunking where it passes through fire compartment walls and floors. In vertical runs of trunking, irrespective of fire resisting barriers at floor levels, where the floor to ceiling height exceeds 3 meters an additional barrier shall be fitted in the trunking mid-way between floor and ceiling.

D. TAP-OFF POINTS

1. All length of trunking shall be provided with tapping positions in accordance with approved manufacturer recommended fittings and accessories and as required for a complete functioning and safe operation.
2. Each tap-off position shall be provided with covers or shutters to screen entry to live busbars when the position is not occupied with a tap-off unit.
3. The tap-off positions shall be arranged so that the plug- in contacts self align with the busbars.

4. Tap-off positions shall be suitable for tap-off units to be plugged in either below or above the busbars.

E. TAP-OFF BOXES AND ACCESSORIES

1. Tap-off boxes shall be rated as detailed in the schedule and drawings
2. Tap-off boxes shall be constructed of sheet and shall be complete with hinged lids and 25 mm conduit entry gland. The boxes shall house MCCB , neutral and earth link and have polarity and rating as detailed in the schedule.
3. Where tap-off boxes are to be inserted into live busbar trunking, they shall be designed and constructed so that current carrying metal is not exposed during insertion or removal and that the box is connected to earth before contact is made with live busbars. The box shall remain earth during removal until all live connections are disconnected. The design shall ensure that the tap-off can only be inserted to give the correct polarity.
4. Where change of direction or termination occurs in a busbar run, the manufacturer's purpose-made bends, tees pieces, cross-overs, reducers, and end covers shall be used.
5. Where breakers are connected to the busbars through tap-off points an interlock shall be provided to prevent removal with the breaker in the 'ON' position.
6. Each tap-off unit shall be fitted with terminal blocks in order to hook up the outgoing cables. The size and rating of these terminal blocks shall be chosen according to the prospective outgoing cable size as indicated in the drawings.
7. Circuit breakers installed inside tap-off units must comply with section 16411 and shall be selective type with all circuit breakers in the project switchboards.

2.2 RECOMMENDED MANUFACTURER

- Refer to list of recommended manufacturer

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which busbar trunking are to be installed. Notify engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. The busbars trunking shall be installed so that the maximum unsupported span does not exceed 3 meters. Any fixings used shall be contractor of mild

steel angle or channel finished to the same standard as the trunking and shall not cause any long term corrosion or electrolytic action.

- B. Where any cutting or damage is caused during erection, the burrs and rough edges shall be removed and the finish made good. Any corrosion which has occurred shall be removed and the area treated with a rust -proof agent. The finish shall then be made good by the application of either a zinc rich epoxy primer or equal alternative, and for class 2 finishes this shall be followed by coat of color matching paint.
- C. Runs of trunking shall not be used to support other equipment or services nor shall any cables be installed in the trunking unless the trunking is specially designed for these purposes.
- D. Where busbar trunking passes through fire barriers , walls, floors and ceilings, fire resting barriers shall be fitted in the trunking and the hole surrounding the trunking shall be made good to the full thickness with fire resisting material to provide fire resistance equal to that of the structure through which the trunking passes
- E. In vertical runs of busbar trunking thrust supports shall be fitted either at each floor level or at 3 meters spacings which ever is the lesser dimension.
- F. Incoming cables and all outline shall be supported to avoid appreciable mechanical loads being imposed on the busbar trunking.

3.3 FIELD QUALITY CONTROL

- A. Prior to installing, test for electrical continuity of bonding, and earthing connections, and to demonstrate compliance with grounding requirements.
- B. Electrically energize Busbar trunking systems and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance. Replace equipment which cannot be satisfactorily corrected.

END OF SECTION 19

SECTION 20
MOTOR CONTROL CENTERS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Single line diagrams and general provisions of contract, including general supplementary Conditions (General Requirements), apply to work of this section.
- B. Raceways, boxes, and fittings section, apply to work of this section.
- C. Cable trays section, apply to work of this section.
- D. Low voltage switchgears section; apply to work of this section.
- E. Instruments and metering section, apply to work of this section.
- F. Safety and motor isolators section , apply to work of this section
- G. Wires and cable section; apply to work of this section.
- H. Automatic transfer switches section, apply to work of this section.

1.2 DESCRIPTION OF WORK

Work includes providing all materials, equipment, accessories, services, and tests necessary to complete and make ready for operation by the owner; all Motor Control Centers (MCCs) in accordance with the drawings and specifications.

1.3 DEFINITIONS

A. Definitions pertaining to electric motors and motor controls are as follows:

- | | | |
|---|---|---|
| 1 | "Motor Power Circuits" | Any circuit, which operates nominally at 220/380V or more, and which carries electrical input energy to a motor. |
| 2 | "Motor Control Circuit" (used in conjunction with a motor for which a magnetic starter is supplied. | Any circuit, (other than a motor power circuit) which operates nominally at 24V, and which carries current intended for controlling or monitoring the performance of a motor starter. |
| 3 | "Motor Control Circuit" in conjunction with a motor for which a manual starter is supplied. | Any circuit containing a used extension of power circuit wires other than those constituting the direct connection between sources of supply, starter and motor. |
| 4 | "Motor control actuating" device. | Any device which performs a switching function in a motor control |

- 5 "Motor control actuated" device. circuit (Pushbuttons, automatic contacting devices, etc.). Any device which operates in response to voltage received from a motor control circuit (pilot lights, solenoids, etc.).

1.4 QUALITY ASSURANCE

Manufacturers: Firms regularly engaged in the manufacturing of Motor Control Centers of the types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

1.5 INTERPRETATION

The process and automatic control systems called for elsewhere, on plans or in these specifications as part of the mechanical work, shall be interpreted as being totally divorced from the motor controls here in after described. These systems, however, do include devices of the motor control actuating, dictating and actuated types which are connected into some motor control circuits as accounted for in the drawings entitled "Motor Control Centers Details".

In case of any conflict between any parts of this specification or any other document elsewhere the material with higher stated specifications must be used. Any conflict or technical misunderstanding should be discussed during bidding phase. The consultant will be the only technical reference for the intents and contents of this document and the contractors will have to follow consultant technical interpretation in case of any conflict arising after bidding stage.

Where differences occur between the Motor Control Centers Panels Drawings and the Mechanical Equipment Data Sheets, the Mechanical Equipment Data Sheets shall take precedence. As the contractor is totally responsible for the coordination with final approved mechanical equipment ratings and quantities.

1.6 MOTORS, MOTOR STARTERS, MOTOR CONTROL ACTUATING AND ACTUATED DEVICES FOR MECHANICAL EQUIPMENT ASSIGNMENT TO TRADES

- A. The purchase and delivery to the site of all motors required for mechanical equipment shall be included as part of the mechanical work.
- B. The setting of all motors required for mechanical equipment shall be included as part of the mechanical work.
- C. The purchase and delivery to the site of all motor starters required for mechanical equipment shall be included as part of electrical work.
- D. The mounting of all motor control actuating, dictating and actuated device required for mechanical equipment shall be included as part of electrical work unless otherwise noted.
- E. The purchase and delivery of motor starters called for as part of a motor control center shall include the purchase and delivery of the entire motor control assembly.

1.7 SUBMITTALS

A. SHOP DRAWINGS

1. Wiring Diagrams

1.1 The supplying of electrical wiring diagrams of manufactured equipment, including terminal to terminal point, integrated electrical wiring diagrams, for power, operating, safety and interlocking/interlock controls shall be included as part of the work. This requirement shall be met regardless of any assignment between trade of the responsibility for the purchase, delivery, setting in place, connecting up of electrical motors, starters, controls and other electrical devices.

1.2 The drawings describing the electrical and/or the mechanical work may include explanatory wiring diagrams indicating the function intended for the motor controls circuits of certain specific motors.

The "field instructions" wiring diagrams required as part of the work shall conform to these intended functions.

2. Dimension layout

The supplying of electrical dimension layout of manufactured equipment shall be included as part of the mechanical work.

B. PRODUCT DATA

Manufacturer's printed data, catalogue cuts and illustrations.

C. SHORT CIRCUIT CALCULATIONS

Contractor shall submit a detailed short circuit calculations based on the final layouts, cable sizes, motor ratings, etc. Motors contribution shall be included in the calculations.

D. VOLTAGE DROP CALCULATIONS

Contractor shall submit a detailed voltage drop calculations based on the final layouts, cable sizes, and motor ratings.

PART 2 – PRODUCTS

2.1 MOTOR CONTROL CENTERS PANELS MECHANICAL AND ELECTRICAL CONSTRUCTION

- A. Motor Control Centers to be manufactured in accordance with BS EN 60439. Provide the Motor Control Centre Panels suitable for internal or external locations with the required degree of protection and form of internal separation indicated. Protection to be as BS EN 60529.

- B. The motor control centers panels shall be constructed as described here under and as shown on the single line diagrams drawings.
- C. **Indoor** located panels to be fully enclosed cubicle type assemblies, fully compartmented type Form 2b/IP54. In all instances the controls must be housed with dedicated and completely separate section.
- D. **Outdoor** located panels to be fully enclosed cubicle type assemblies, fully compartmented type Form 2b/IP65. In all instances the controls must be housed within a dedicated and completely separate section.

- E. Panels to be modular form with modules not exceeding 1200mm wide, 2200mm high or a weight of 0.5 tonnes. Provide removable lifting eyes at suitable locations for modules over 50kg.

Lifting eyes shall be provided at reinforced points on the top of all panels. Suitable plugs (steel or PVC) shall be provided to cover the holes after the eyes have been removed to prevent the ingress of dust and water to the specified IP rating.

- F. Provide sufficient but at least one gland plate per each cubicle for cables to enter and leave the panel. Gland plates to be suitable for the imposed loads of trunking, conduit and cables. Trunking and conduit to be made off onto the gland plates.

Cable or trunking access shall be required for suitable entry on top or bottom of the panel as dictated by the panel location. Removable bolt-on gland plates shall be provided at these entries and the plate shall be adjacent to the appropriate terminal bar.

- G. All accessories mounted through the panel skin shall be suitably rated and fully compliant with the specified IP rating.

- H. Provide panels of best quality folded zinc coated mild steel sheet minimum thickness 1.6mm, braced and stiffened where necessary. Panels to be degreased and chromate etched, followed by two coats of primer and stove enameling. Internal surfaces and component mounting plates shall have a matt white finish.

- I. Panels shall be of welded construction using zinc coated mild sheet steel, braced and stiffened where necessary.

All external edges and corners shall be rounded (i.e. either formed or suitably dressed to prevent sharp edges and corners). Any cutting of manufactured finished surfaces shall be de-burred and left without sharp edges or protrusions.

- J. Internal partitioning plates separating compartments shall be sheet steel.

Panels up to 1200mm x 1200mm may be wall mounted. Larger panels to be floor mounted on 100mm builders work in concrete or purpose made integral plinths. Rodent screens to be provided to prevent rodent entry into panels.

- K. All panels to incorporate the following:-

- 1- 1 No. Main Incoming Lockable Isolator
- 2- Circuit breakers for each item of plant

- 3- 1 Digital multi-meter
- 4- Hinged and lockable flush mounting access doors
- 5- 2 Identical keys for every lock and panel
- 6- 1 Mains incoming neutral link
- 7- 1 Set Control of miniature circuit breaker for low voltage transformer
- 8- 1 Test switch for operating control voltages only with all power circuits de-energized
- 9- 1 Set numbered terminals
- 10- 1 Set engraved labels to BS5378 Part 1
- 11- BMS control outstation
- 12- 1 set indicating lamps (Run, trip and alarm)
- 13- 1 lamp test facility (common)
- 14- 1 Power ON lamp
- 15- Space for future expansion (20%)
- 16- Common and remote alarm terminals
- 17- Audible alarm and mute/test facility
- 18- Earth bar with test link

- L. All motors to have three position Hand/Off/Auto switches with run and trip lights. In the hand position no safety features or interlocks are to be overridden.
- M. Within the controls section a surface mounted single switched metal clad socket to BS 1362 shall be fixed supplied from a 10A miniature circuit breaker fed through earth leakage circuit breaker. This is for use by the controls specialist, for lap top computers, data logging equipment or test sets, in addition to regular maintenance cleanups using blowers. This socket and associated 220volt supply cabling shall be suitably segregated for from the control wiring and devices.
- N. Each panel cubicle shall be provided with internal fluorescent lighting strip energized when door switch is toggled.
- O. Ventilation fans shall be incorporated as required to maintain the internal temperature below the working temperature of the internal components.

2.2 WIRING AND TERMINATIONS

- A. All low voltage wiring shall use PVS insulated cable, Power wiring (between MCC and each load) shall be stranded with a minimum cross sectional area of 2.5mm^2 - phase colored XLPE/PVC insulated multi-core or single core cables depending on design requirements and BOQ conditions. Control wiring (24V) shall be of flexible type with a minimum cross sectional area of 1.5mm^2 - red.
- B. Maintenance load break switch shall be installed beside every motor to ensure safety while performing regular maintenance operations for all equipment.
- C. Provide control circuit transformer and use 24 Volt AC operating supply to suit control components. Segregate control wiring from power wiring. Provide ventilated plastic trunking for control wiring. Identify each end of the wire with a unique number using color coded 'O' ring markers. Fit lugs at termination points. Use cabling of 1.5mm^2 minimum and of the LSF high temperature rating (Tri-rated). Life safety control wiring and interfaces with fire alarm and fireman's override shall be in fire resistant cable e.g. Pirelli FP400 to BS 6387. See fire alarm and electrical specification for fuller details.
- D. All control circuits shall use the red phase and shall be wired in red cable.

- E. All neutral wiring shall be in black cable.
- F. The color coding shall be as follows:
 - 1. Phase connections - red, yellow and blue.
 - 2. Neutral connections - black.
 - 3. Earth connections - green/yellow.
 - 4. a.c. voltages below 50V - brown; if the return connection is earthed a green ferrule shall be fitted.
- G. Wiring shall be carried on the front surface of the mounting plate, neatly strapped in plastic cable trunking of the ventilated type, with clip-on covers. Cable sizes shall be rated taking into account all grouping, bunching and enclosing factors.
- H. All wiring to the switch section doors shall be wired in looms with mechanical protection. Any one loom of control cables shall have a limit of 25 cables within the plastic trunking volume. Wiring outside the trunking shall be neatly set for connection to terminals or equipment.
- I. All control wiring shall be identified with numbered ferrules. These numbers shall be shown on the schematic wiring diagrams. Control neutral wiring shall be of the ring main principle with no more than 20 items on any one ring.
- J. Panel wiring for DDC controls shall be in screened flexible cable. Extra low voltage wiring and terminals shall be separated from wiring and terminals for higher voltages.
- K. Each screened cable shall have its screen wired to its own terminal on the outgoing terminal strip.
- L. The screen shall be earthed at the equipment and not at the terminal strip.
- M. All control wiring shall be fitted with crimped terminal ends.
- N. All power wiring shall be fitted with crimped terminal ends where the terminal is of the 'pinch screw' type.
- O. Terminals shall be of the suitably rated, fully numbered and fitted so that extra units may be added.
- P. They shall be suitably sized to cater for long runs of externally mounted cable where voltage drops necessitate a larger size than standard for the connected load.
- Q. 20% spare terminals shall be fitted to each control panel. Each terminal rail shall have sufficient length for 10% additional terminals.
- R. All wiring for DDC devices shall be via screw type terminals.
- S. Entry to the panel terminals shall be via detachable, undrilled gland plates. Gland plates shall cover the length of the terminal strip.
- T. All panel mounted equipment shall be wired out to terminal strips.

- U. Equipment earthing connections shall be provided, and sized according to the anticipated short circuit current. Earthing connections shall be sufficiently tight to assure permanent and effective earthing for the MCC enclosure.

2.3 EQUIPMENT - ISOLATORS

- A. The used main isolating load break switches and fuse switches where used, shall be capable of opening and closing on-load. Isolating switches shall conform to utilization category AC-3. Isolating switches and circuit breakers shall comply with the requirements of BS EN 60947. Isolating switches and circuit breakers shall be suitable for 50 Hz, 3-phase, 4 wire connections.
- B. Individual starter isolators shall conform to AC-3, utilization category.
- C. A bolted neutral link shall be provided for termination of the incoming cable.
- D. maintenance disconnect switches shall be provided for all served mechanical loads, for star/delta starters a 6-pole disconnect switch complete with auxiliary switch shall be utilized.

2.4 SHORT TIME RATING & FAULT LEVELS

Short time ratings and fault levels are shown on the Electrical drawings and they should be calculated by the contractor and submitted for approval.

2.5 STARTERS

- A. Shall comply with BS EN 60947 Part 4 and be suitable for starting standard industrial cage or wound rotor motors or as specified in the particular specification.
- B. Starters shall be rated for continuous duty unless otherwise specified on drawings or schedules.
- C. Utilization categories for contactors in all types of starter shall be IEC 60947 AC-3 unless otherwise specified for particular applications.
- D. Provide short circuit protective devices to each outgoing circuit. Protection to be circuit breaker sized to suit the full load and starting effects of the connected device. Ensure type 2 co-ordination to IEC 947.
- E. Circuit breakers to be manufactured to BS EN 60947.
The used circuit breakers types shall be as follows:
 - 1- Circuit breakers feeding loads up to 0.75kW shall be of the miniature type.
 - 2- Circuit breakers feeding loads 1-7.5kW shall be of the Manual Motor Starter or Motor Circuit Breaker type.
 - 3- Circuit breakers feeding loads greater than 7.5kW shall be of the Moulded case type.
- F. Motor starters types shall be as follows:
 - 1- Motors up to 0.75kW, 220V, D.O.L.

- 2- Motors 0.75kW – 5.5kW, 380V, D.O.L.
- 3- Motors 7.5 kW to 45 kW, 380V, Star Delta
- 4- Motors > 45 kW Soft Start

- G. All starters and speed control systems shall be provided with suitable protection for phase to phase, phase to neutral and phase to earth faults, overloads, under voltage, over voltage, phase sequence, and phase failure.
- H. All overload devices shall be arranged for hand resetting. A reset button shall not be provided on the starter enclosure. All overload relays shall have load contacts of the single-pole changeover type.
- I. Motor starters shall be provided with bolt-free auxiliary contacts for local and remote signaling.
- J. Soft starters do not apply for any life safety motor (i.e. smoke fans)

2.6 DIRECT ON LINE (DOL) STARTERS

DOL starters shall be rated for intermittent periodic duty or intermittent duty class 0.3 and comply with the requirements of utilization category AC-3.

2.7 AUTOMATIC STAR-DELTA (ASD) STARTERS

- A. In all types of star-delta starters the correct phase relationship between the star and delta connections to minimize disturbance on changeover shall be maintained.
- B. In all star-delta starters the star and delta contactors shall be electrically and mechanically interlocked so that they cannot close or be closed at the same time.
- C. Where overload relays are connected in the phase circuit the overload relay scales shall be clearly marked to show whether they represent line current or whether the scale must be multiplied by 1.7 to represent line current.
- D. Automatic changeover timers shall be adjustable from one second up to at least 20 seconds but the transition from star to delta windings shall be achieved without any internal delay. Closed transition timers shall have tamper-proof factory-set adjustment.

2.8 STARTERS FOR DUAL-WOUND AND POLE-CHANGE MOTORS

- A. Shall be electrically and mechanically interlocked so that it is impossible for both high and low speed contactors to close or be closed at the same time.
- B. The parts of the composite starter shall comply with the relevant specification for individual starters.
- C. Adjustable timers shall be fitted into the control circuit so that there is a time delay between switching off the high speed contactor and switching on the low speed contactor.
- D. When high speed is selected the motor shall run in low speed for a preset time before changing to high speed.

2.9 SOFT-START/STOP STARTERS

- A. Soft start/stop starters shall be supplied as a unit with an enclosure suitable for panel mounting.
- B. Starters shall be rated for 380V a.c., 50Hz supply and a temperature operating range of 0 to 40 °C. Noise and impulse immunity shall be to, IEC 60947-4-2.
- C. Soft start shall be via a range of switch selectable ramp times of between 0.5 and 60 seconds with a ramp voltage which increases linearly with time.
- D. Soft stop shall be via a range of switch selectable ramp times of between 1 to 120 seconds.
- E. The control circuit shall incorporate a remote emergency stop facility.
- F. This function shall override the normal 'soft stop' of the starter.
- G. Filters shall be provided at the inlet and outlet of such devices.
- H. The harmonic current spectrum of each soft-start/stop starter shall be provided by the manufacturer for the calculation and provision of suitable filtration at the electrical switchboard.
- I. A contactor shall be provided which isolates the soft start/stop unit when the motor is not required to run. The contactor shall be arranged to switch 'off-load'.
- J. The maximum starter current shall be 2.0 times full load.
- K. The control panel manufacturer shall calculate the maximum heat dissipation from all soft-start devices and incorporate adequate ventilation/cooling methods to ensure that the internal temperature within the panel does not exceed 40°C. The calculations shall be submitted for the approval of the consultant.

2.10 VARIABLE SPEED (FREQUENCY) DRIVES (VSDs)

2.10.1 GENERAL:

- A. The frequency drive shall employ Pulse Width Modulation (PWM), or Pulse Vector Modulation (PVM) using thyristor or transistor switches.
- B. The rating of the frequency drive shall be sufficient for the continuous maximum rating of the motor and not it's running load.
- C. The frequency drive unit shall have efficiency in excess of 90 %.
- D. The frequency drive shall be capable of switching on to a motor already rotating in either direction.
- E. The contractor shall calculate the maximum heat dissipation from all VSDs and incorporate adequate ventilation (or cooling if needed) methods to ensure that the internal temperature within the drive does not exceed 35°C. The calculations shall be submitted for consultant approval.

2.10.2 TECHNICAL FEATURES

- A. The input to the frequency drive shall be of an uncontrolled bridge rectifier type, to limit harmonic distortion.
- B. The speed shall be smoothly adjustable, and controlled by one of the following:
 - 1. Potentiometer (Manual/hand operation)
 - 2. 0-10V dc signal (Auto operation)
 - 3. 4-20 m A signal (Auto operation)
- C. Overcurrent, short-circuit and earth fault protection of the output shall be provided within the control system. Reset of any fault condition shall be manual.
- D. The system shall provide protection against phase loss. If not included within the frequency drive, then an external phase loss detection device shall be fitted.
- E. Full rated output shall be provided continuously with an ambient temperature of 50 °C and 90% relative humidity the control panel manufacturer shall ensure that sections of the panels housing frequency drives shall be suitably ventilated and/or cooling to ensure that this temperature is not exceeded.
- F. The starting arrangement shall include a ramp speed control, to achieve starting currents not exceeding normal full load current wherever possible.
- G. The output frequency range shall nominally be 0.5 to 120 Hz.
- H. The variable speed drive digital display screen shall provide the following visual information :
Motor Speed, Motor Power (kW), Motor full load frequency loading percentage, and actual drawn current.
- I. The VSD shall be capable of providing the following points to the BEMS:
 - a. Motor fault (short circuit, overload, phase failure, and overheat).
 - b. Motor status (Running).
 - c. Motor reference analogue pints (speed, power, current, and loading percentage).
- J. The VSD shall be equipped with standard communication protocol for full interface with BEMS (Bacnet, LON, or ModBus).
- K. The control circuits shall be immune to interference caused by operating on normal raw mains supply in an industrial environment.
- L. Where variable speed drives systems might be a source of Radio Frequency Interference (RFI) sufficient to interfere with the proposed functioning of adjacent computer based equipment, RFI suppression at source shall be applied.
- M. VSDs shall be equipped with harmonics filters to ensure a maximum of 5% deviation.
- N. The manufacturer shall provide details regarding the production of mains-borne interference and harmonic. Written guarantees shall be given by the manufacturer

that these levels of interference and harmonics shall not be exceeded over the full operating speed of the drive.

- O. Where screening of cables between the frequency drive and motor is required, the type of cable recommended must be indicated at the tender stage. The recommended cable must ensure that the level of any radio interference is limited to comply with BS800.
- P. The harmonic current spectrum of each frequency drive shall be provided by the manufacturer for the calculation and provision of suitable filtration at the electrical switchboard.
- Q. All drives shall be IP-54, unless otherwise mentioned.

2.11 BUSBARS

Provide suitably sized phase bars with full neutral and full earth, fully insulated, fully compartmentalized primary and secondary busbars. All joints and interconnections to be accessible for inspection and tightening.

Busbars shall be rated and constructed in accordance with BS 159. Neutral bars shall be the same size as the phase conductor bars.

The busbar system shall be housed separately from the panel control sections.

The busbar system shall be clearly marked in red capital letters on a white background:

“WARNING – LIVE BUSBARS. SWITCH MAIN ISOLATOR OFF BEFORE REMOVING THIS PANEL” or a similar wording approved by the CA.

Copper busbars shall be air insulated and the phases and neutral bars shall be color identified. The minimum size of the bars shall be 25mm x 4mm.

Busbar chambers shall be arranged for ease of future extension to accommodate further sections.

All holes or apertures into the busbar chamber must be sealed to prevent access to live busbars by operatives when working in the main panel or any panel compartment.

2.12 CONTACTORS

- A. Shall be of the same manufacturer as the starters. They shall be suitable for use on 3 phase, 4-wire 400/230V, and 50Hz supplies and fitted with 24V 50Hz coils.

Contactors shall comply with BS EN 60947 Part 4 and shall be rated for intermittent periodic or intermittent duty Class 0.3.

The utilization category shall generally be AC-3 but category AC-1 may be used where the load is positively identified as being non-inductive, but excluding tungsten filament lamps.

2.13 RELAYS

Relays shall be fitted with 24V, 50Hz coils. All relays shall have a clearance of 3mm between them.

2.14 TIMERS

Shall be electronic with adjustable ranges.

2.15 INDICATOR LAMPS

Use 12 volt low wattage filament indicator lamps color coded as follows:-

Red	-	Trip/Alarms
Yellow	-	Duty
Green	-	Run
White	-	Supply Healthy

Lamps to be flush mounted with lamp changing from the front. Lamps to be mounted on access doors.

2.16 FUSES

- A. Fuses shall comply with the requirements BS EN 60947
- B. Where Applicable panels shall be provided with a spare set of fuses. When commissioning is complete the panel is to be handed over with this complete set of spare fuses provided as part of the Controls Sub-contract.
- C. HRC fuses are to feed all pilot lams, while the control circuit of each starter and other 220/24V circuits shall be fed through MCB.

2.17 Digital Multi-meter

Digital multi-meter complete with full voltage, current and Hertz measurements to be connected to BMS station via LON or MODBUS communication network.

Current transformers to be used for ammeters greater than 40A.

2.18 Safety Interlocks and Padlocking

Where applicable provide padlocking facilities to each outgoing circuit to enable safe working procedures.

Provide hard wired and mechanical interlocks for all safety devices or procedures (i.e. not software generated).

2.19 Earthing

Provide an earth busbar system across each compartment for ultimate connection to the Building earthing system.

The unit earthing system shall be capable of carrying the full rated fault current for 1 second. Comply with BS 7430.

2.20 Discrimination

Provide verification that final selection of protective devices ensures correct electrical discrimination.

2.22 GENERAL

- A. Each starter/contactors shall be controlled from a Manual-off-Auto switch on the panel facade. Each starter/Contactors shall be provided with RUN/TRIP Indicating lamps as shown on the drawings.
- B. The RUN position on all selector switches shall allow its associated plant to run out of normal sequential control provided all safety interlocks are satisfied. This facility is primarily for commissioning/maintenance purposes.
- C. Wiring arrangements shall permit all starters/contactors to be de-energized from remotely mounted lock-off stop buttons or local isolator auxiliary contacts.
- D. Indicator lamps shall be provided for indicating the presence of each incoming phase to panels.
- E. Indicator lamps shall be provided to indicate that the 220 V control circuit is healthy. A push button connected to all lamps will be used as a lamp test method to check the functionality of the lamp.
- F. A 13 Amp switched socket outlet shall be provided within each panel fed via an ELCB from the live side of the main panel isolator.
- G. Each section of the control panel shall have an internal long fluorescent strip light. They shall, in the case of multiple section panels, be controlled by a single switch with an indicator lamp on the main isolator section.
- H. The panel shall be suitably wrapped for delivery to site with 500 grade anti-static polythene.
- I. Each panel section shall be provided with a lifting eye in each corner.
- J. Unless otherwise indicated, enclosures degree of protection will be IP 55 for indoor use, while it should be IP-65 for outdoor use.

2.23 AS-BUILT DRAWINGS

- A. The following CAD prepared drawings shall be provided for each panel:
 - 1. Schematic internal and external wiring diagrams.
 - 2. General arrangement drawings detailing internal and external equipment layouts.
 - 3. Detailed label engraving drawings.
- B. A drawing pocket shall be provided in each control panel.

2.24 TESTING

- A. All wiring within control panels shall be works checked, prior to dispatch, for loose connections, correct terminations and compliance with wiring diagrams. In addition, functional checks shall be carried out in the works to ensure that all interlocking and sequencing is in accordance with the performance requirements of the specification. The Owners Authorized Representative shall be given seven days written notice of such tests so that he may attend if he so desires.
- B. With all control circuits disconnected but with all isolators closed and power fuses fitted, the panels shall be subjected to a High Voltage test of 2.5kV for one minute, across the following points:
1. Phase to phase
 2. Phase to neutral
 3. Phase to earth
 4. Neutral to earth
- C. This shall be followed by an insulation resistance test with an approved type of 500V testing instrument.
- With all electronic components removed and with all isolators closed and power fuses fitted, an insulation resistance of not less than 20 Mega ohms shall be obtained between each of the following points:
1. Phase to Phase
 2. Phase to neutral
 3. Phase to earth
 4. Neutral to earth
- D. Certified schedules detailing all tests and their results shall be submitted to the Engineer within fourteen days of the tests.

2.25 APPROVAL OF STANDARDS

The standard of workmanship shall comply with the requirements of the Engineer who shall carry out periodic inspections of completed work and work in progress.

2.26 SCHEDULES

- A. Details of the panels are included in the Motor Control Panel Drawings.
- B. The BEMS specialist should coordinate the motors and control equipment quantities and ratings with the other trades and take any approved corrections at no cost to the contract.

2.27 SCOPE OF WORKS

- A. The Contractor shall supply all controls and controls related equipment detailed within this specification. Any items of equipment or works not specifically mentioned in this specification but necessary for the correct or safe operation of any item of plant shall be deemed included in the contract scope of works.
- B. The Contractor responsibilities shall include but not be limited to the following:
1. Supply of all drawings detailed in Section A of this specification, produced using

AutoCAD Version 2005 or above.

2. Supply, manufacture and works testing of all motor control panels.
3. Supply and fit hardboard protection on all sections of above panels and enclosures, in such a manner that allows free operation of doors, facade mounted switches, push buttons etc, to protect the paint work during commissioning.
4. Storage as necessary, transportation and installation of all motor control panels and enclosures.
5. Supply and installation of all sub-main power cabling from the motor control panels and enclosures to each item of plant.
6. Identification of all sub-mains power and controls cabling from the motor control panels at both ends of each core, using the same numbering as its associated outgoing MCC/enclosure terminal.
7. Ensure all control devices are positioned such that maximum stability of control for each system can be achieved.
8. Supply and fit an engraved 'Formica' label for all controls items, equipment and plant associated with the control system, incorporating the appropriate identification reference number as detailed on the Motor Control Panel Equipment Schedules.

All labels shall be fixed with bright finish instrument head screws or plastic flat headed push in rivets of the same color as the label.

9. Supply and compile documentation and training as detailed in Section A of this specification.
10. Warranty of the entire system for 12 months following Practical Completion.

When submitting his, the contractor shall tender clearly describe any work necessary for the proper completion of his package which has not been included for in his tender and which he may require to be executed and paid for by others; any such work not specifically stated and described shall be deemed to have been included in his tender.

2.28 ELECTRICAL - GENERAL

- A. The equipment supplied shall be suitable for operation on 380/220V, 50Hz supplies. Any special tolerances, screening and earthing requirements shall be included in the contractor scope of work.
- B. In order to avoid corruption of the BEMS equipment operation by electrical interference, all wiring shall be installed to minimize coupling of electromagnetic and electrostatic interference to low bulldog signal and data wiring. The preferred method of achieving this shall be by ensuring a physical separation of greater than 50 mm between the power supply cables and the signal and data cables. Where mixed wiring is unavoidable braided screen mains cable, dressed close to metalwork, is preferred, but the **Contractor** shall clearly specify the methods by which he intends to eliminate any such interference with his signal and data transmission.

- C. The contractor shall provided 10% of spare components referred to the total number of MCC components of the whole project, taken for all types, sizes, and ratings of circuit breakers, load break switches, maintenance disconnect switches, contactors, thermal overload relays, control relays, selector switches, indication lamps, internal fluorescent lighting.

PART 3 - EXECUTION

3.01 BUILDERS WORK

- E. The Contractor shall include for all cutting away, structural holes and foundations required for the controls system, as detailed with marked up drawings, via or by the Controls Specialist, together with all the necessary making good after such work.
- F. The Contractor shall include for all scaffolding and working platforms required by the Controls Specialist including the setting up and taking down of such items.

3.02 INTERCONNECTION WITH OTHER SYSTEMS

- A. The contractor is totally responsible to workshop drawings to assure provision and compatibility with all required data points as per schedule of points and control schematics of the BEMS and Fire alarm packages.

END OF SECTION 20

SECTION 21

LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions (General requirements), apply to work of this section.
- B. Basic electrical materials and methods, section 16050 applies to work of this section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services and tests necessary to complete and make ready for operation all lighting fixtures, ballasts, and lamps in accordance with Drawings and Specifications.
- B. All information contained in the fixture schedule, fixture cuts, layouts and specifications shall be considered to form a complete and integrated specification for lighting fixtures. The contractor is responsible for contacting the architect regarding the proper interoperation of all information indicated on the lighting fixture schedules, fixture cuts and details, the electrical plans and the reflected ceiling plans.
- C. The contractor is responsible for all fixture quantities, lengths and clearances required. The contractor shall inform the architect of project conditions which affect installation or fixture location at the time submission is made.
- D. Any exception to the following specifications shall be qualified in writing by the contractor prior to the submission of bids. Only upon the contractor's receipt of the architect's written approval of the requested exception shall the contractor's bid be accepted by the owner.
- E. At each location shown on the drawings, furnish and install a lighting fixture of the type indicated.
- F. Furnish and install all materials, accessories and other equipment necessary for the complete and proper installation of all lighting fixtures included in this contract.
- G. Fixtures shall be manufactured in strict accordance with the contract drawings and specifications.
- H. Specifications and scale drawings are intended to convey the salient features function and character of the fixtures only, and do not undertake to specify every item or detail necessary. Minor details necessary for the proper execution and completion of the fixtures not indicated on the drawings nor specified shall be provided as if they were specified here or indicated on the drawings. Parts not specifically identified shall be made of materials most appropriate for their intended use.
- I. The owner shall not be held responsible for the omission or absence of any detail, construction feature, etc. which may be required in the production or

installation of the lighting fixtures. The responsibility of obtaining all information necessary for accurately fabricating the lighting fixtures to the fulfillment of this specification rests with Contractor.

1.3 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in the manufacture of lighting fixtures, ballasts, and lamps, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Standards Compliance: Comply with requirements of applicable local codes, DIN/VDE and IEC Standards pertaining to lighting fixtures, ballasts, and lamps. Provide lighting fixtures, ballasts, and lamps products and components which have been labeled by approved authorities.
- C. In case of conflict among the referenced standards and codes, the more stringent provision will govern.
- D. Materials, equipment and appurtenances as well as workmanship provided under this section shall conform to the highest commercial standard.
- E. The contractor shall coordinate the lighting fixture installation with the drawings and details of the architectural, structural, electrical, mechanical, and all other related trades to assure a perfect and efficient installation.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's data for lighting fixtures, ballasts, and lamps; include the following:
 - 1. Details of construction and finishes
 - 2. Electrical ratings
 - 3. Mounting
 - 4. Photometric data
 - 5. Submit samples as directed by the Engineer.
 - 6. Drawings to scale
 - 7. Lighting track
- B. Samples : Submit sample for each type of lighting fixture specified in the lighting fixtures schedule for review and approval.
- C. Test : Submit type test certificates for the specified lighting fixtures.
- D. Shop drawing of all custom or modified standard lighting equipment shall be submitted in reproducible sepia form only. Shop drawing shall be drawn at either full size or half-full size wherever practical. Shop drawings shall illustrate a minimum of three (3) critical views indicating all fabrication and assembly methods, materials, material gauges and finishes to be employed, electrical supply, mechanical support, electrical accessories, etc. shop drawings of custom and modified standard fixtures shall clearly indicate the fixture type, the drawings referenced in the development of the shop drawings and the names of the project, architect and lighting Consultant. Shop drawings of standard fixtures shall clearly indicate the fixture type and space permitting, the names of the project, Architect and lighting Consultant.

- E. Submittals lacking sufficient detail to indicate compliance with contract documents will be **rejected** without review and penalty for delay will borne by the Contractor.
- F. Fixtures substitutions (From manufactures other than those listed as approved equal) shall be equal in all respects of performance, quality of construction, suitability to project conditions and appearance of the specified fixture. Substitutions shall be submitted for approval in the form of catalog cuts or detail drawings not later than three weeks after bids are due to allow for timely processing. Upon request submit samples of substitute fixtures for approval. Upon request, submit certified photometric and head test reports from an independent testing laboratory for approval before fabrication. Disapproved substitutions shall be withdrawn and a submission for a listed approved manufacturer.
- G. "Approved Equal" specification statues does not exempt the identified manufacturer from full and complete compliance with all criteria identified either in the specification or as attributed to " prime specification " equipment with regard to photometric performance, brightness control, aperture size, finishes, trim configuration, etc.
- H. No variation from the general arrangement, dimensions and details indicated on the drawings shall be made on the shop drawings unless required to suit field conditions, and then only with the written approval of the Architect. All variations must be clearly marked as such on drawings submitted for approval.
- I. Dimensions and configurations of continuous fixtures shall be field verified by the fixture manufacturer.
- J. Shop drawings shall be submitted for approval before fabrication. Fabrication details may vary slightly from those shown on drawings provided those changes do not adversely affect ease of installation, durability, performance or appearance of fixture.

PART 2 - PRODUCTS

2.1 RECOMMENDED MANUFACTURER

Refer to list of recommended manufacturers.

2.2 GENERAL

- A. All luminaires shall be manufactured to IEC 60598-1 and 60598-2.
- B. All materials and installation shall be in accordance with the latest revision of electrical code dopted by the local municipality and all applicable federal, state and other codes and regulations.
- C. All luminaires supplied by the contractor shall be photometrically tested.

The contractors shall produce upon request, the photometric data for any luminaire specified or supplied.
- D. All luminaires shall be provided with a lamp compatible with the control gear used.

- E. Luminaires shall not be suspended by their flexible cord. A separate means of suspension shall be provided.
- F. All flexible cords shall be anchored at both ends such that the cord is free from strain.
- G. Any plastics used in the luminaire shall be light and UV stable and shall be suitable for their application.
- H. All sheet steel components shall be suitably pre-treated and electrostatically spray-painted using acrylic polyester or epoxy powders.
- I. Non-compatible materials shall not be used in contact with each other.
- J. Louvers shall be restrained to prevent them from falling out of the body of the luminaires under normal conditions and when re-lamping. Metal louvers shall be earthed to the body of the luminaire or the earth terminal.
- K. Diffusers shall be restrained to prevent them from falling out of the body of the luminaires under normal conditions and when re-lamping.
- L. Luminaires fitted with high frequency or electronic control gear shall be disconnected before the circuit is tested for insulation resistance.
- M. All luminaires designed for internal use shall be constructed to IP 20 and be Class 1 unless otherwise stated.
- N. All luminaires designed for external use shall be constructed to minimum classification of IP 44 and be class 1 unless otherwise stated.
- O. All materials, accessories, and other related fixture parts shall be new and free from defects which in any manner may impair their character, appearance, strength, durability or function.
- P. All sheet metal work shall be free from tool marks and dents, and shall have accurate angles bent as sharp as compatible with the gauges of the required metal. All intersections and joints shall be formed true of adequate strength and structural rigidity to prevent distortion after assembly.
- Q. All castings shall be exact replicates of the approved patterns and shall be free of sand pits, blemishes, scales and rust, and shall be smoothly finished. Tolerance shall be provided for shrinkage of the metal castings to assure accurate fit.
- R. All screws, bolts, nuts and other fastening and latching hardware for steel and aluminum fixtures shall be cadmium or equivalent plated. All screws, bolts, nuts and other fastening and latching hardware for stainless steel fixtures shall be stainless steel or bronze.
- S. All lamp sockets in lighting fixtures shall be suitable for the specified lamp(s) and shall be set so that the lamp(s) are positioned in optically correct relation to all lighting fixture components. If adjustable socket positions are provided, socket shall be preset in factory for lamp(s) specified. ii different socket positions are specified for same fixture, sockets shall be preset for each type, and cartons marked accordingly. Where modified / standard fixtures are

specified, fixtures shall be modified as required with lamp sockets positioned to provide desired photometric performance.

- T. All lighting fixtures which have a beam angle adjustment shall have reliable angle locking devices. All lighting fixtures with lamps that produce oval beam patterns shall contain lamp orientation locking devices to insure that beam orientation is not disturbed during relamping or cleaning. Each light fixture which has a spread lens shall contain lens orientation locking devices to insure that lens orientation is not disturbed during lamp replacement or cleaning.
- U. Housings shall be constructed so that electrical components are easily accessible and replaceable without removing fixtures from their mountings or disassembly of adjacent construction. All fixtures shall be factory1 pre-wired.
- V. All fixtures and ballasts must operate within the temperature limits of their design and as specified by Underwriters Laboratories, Inc. for the applications and mounting conditions specified. Recessed fixtures installed in insulated ceilings shall be provided with thermal protection.
- W. Install each fixture properly and safely. Provide necessary structural supports where required for the safe attachment of all lighting fixtures. Furnish and erect hangers, rods, mounting brackets, supports and other equipment required. Coordinate conduit entry locations with fixture manufacturers prior to roughing.
- X. Contractor shall be responsible for matching fixture rough-in and trim configuration with ceiling system(s). Determine surface types from the Architectural drawings and furnish lighting fixtures with trim appropriate for the ceiling system(s) the fixture is to be mounted in. If required by the ceiling system(s), furnish a suitable mounting frame or ring for each recessed and semi-recessed fixture.
- Y. Install pendant lighting fixtures plumb and true, at the height from the floor specified on the drawings. In cases where conditions make this impractical, refer to the Architect for a decision. Use ball aligners and canopies on pendant fixtures unless noted otherwise. Rigidly align continuous rows of lighting fixtures for true in-line appearance. Support all lighting fixtures independently of duct work or piping. Whenever a fixture or its hanger canopy is applied to a surface mounted outlet box, provide a finishing ring to conceal the outlet box.
- Z. Lighting fixture locations in mechanical and electrical equipment rooms are approximate. Coordinate mounting height and location of lighting fixtures with other trades to clear mechanical, electrical and plumbing equipment and to adequately illuminate meters, gauges and equipment that requires periodic servicing or inspection.
- Z1. In all uplight coves; fluorescent, cold cathode, incandescent, low voltage, etc., fixtures shall be installed so as to provide a continuous and visually unbroken band of light. Socket shadows, dark spots or visible light gaps are not acceptable.
- Z2. Each lighting fixture shall be packaged with clear, complete installation instructions. Install lighting fixtures in strict conformance with manufacturer's recommendations and instructions.

- Z3. Splices in internal wiring shall be made with approved insulated wire nut¹ type mechanical connectors, suitable for the temperature and voltage conditions to which they are subjected. All wiring shall be suitable for temperature, current, and voltage conditions to which it is subjected, including internal wiring between individual lamp sockets, lamp auxiliaries, etc.
- Z4. Effectively protect all lighting equipment against damage from the time of fabrication to final acceptance of the work. Install reflector cones, baffles, aperture plates, light controlling element for air handling fixtures, and decorative elements after completion of ceiling tiles, painting and general cleanup. Replace blemished, damaged or unsatisfactory fixtures as directed.

2.3 REFLECTORS, TRIMS AND LENSES

- A. Reflectors, cones or baffles shall be absolutely free of spinning lines, ripples or any marks or indentations caused by riveting or other assembly techniques. No hardware shall be visible after installation.
- B. Lenses, reflectors, reflector cones and visible trim of all lighting fixtures shall not be installed until completion of plastering, ceiling tile work, painting and general cleanup. Trim specified to be painted to match surrounding conditions shall be removed from the fixture housing prior to painting and be allowed adequate (minimum 24 hours) drying time before insertion into housing. Trims shall be carefully handled to avoid scratching or fingerprinting and shall be completely clean at the time of acceptance by the Owner.
- C. Optical lenses shall be free from spherical and chromatic aberrations and other imperfections which may hinder the functional performance of the lenses.
- D. Lenses, louvers, or other light diffusing elements shall be removable, but positively held so that hinging or other normal motion associated with cleaning or relamping shall not cause them to drop out. All removable trims shall be provided with safety chains or cords.

2.4 FINISHES

- A. Ceiling opening frames shall either be manufactured of nonferrous metal, or be suitably rust-proofed after fabrication.
- B. Unless otherwise noted, the finish and color of all exposed metal parts shall be as selected by the Architect from the fixture manufacturers standard finish range.
- C. After fabrication and before final painting, give ferrous metal surfaces a five stage phosphate undercoat treatment or other acceptable base bonding treatment, except for stainless steel surfaces.

2.5 LAMP HOLDERS

- A. Incandescent and high density discharge lamp holders shall be fabricated of porcelain with a nickel plated brass screw shell. Pre-lubricate lamp holders with silicone compound. Provide medium base sockets for lamps to and including 250 watts (rated for 1500W, 600V service) unless specified

otherwise. H.I.D. amphoters shall be heavy duty pulse-rated type.

- B. Linear and compact fluorescent lamp holders shall be fabricated of heavy white thermoset urea plastic with a definite locking-in feature and silver plated contacts. Exposed outdoor lamp holders shall be compression neoprene gasketed type. Sockets with open-circuit voltage over 300 volts shall be safety type designed to open supply circuit on lamp removal.

2.6 INCANDESCENT LUMINAIRES

- A. Luminaires for incandescent light sources shall be designed to accommodate the specified lamp.
- B. Where the specified lamp is either unsuitable for the luminaire or the construction of the luminaire is liable to affect the life of the specified lamp alternatives shall be offered to the Owner's Authorized Representative.
- C. Care shall be taken in handling quartz envelope lamps, where the lamps should not be handled directly. Where this does occur, the lamp should be cleaned using a soft cloth moistened with white spirit.
- D. Luminaires using low voltage tungsten halogen lamps shall each be supplied complete with its own transformer unless otherwise stated.
- E. Wire wound transformers shall be rated at 230/11.8 V and comply with IEC 742, Class II and be insulated to Class H of IEC, DIN/VDE standards.
- F. Transformers shall be protected against overload and short-circuiting.
- G. Where multi point transformers are specified voltage regulation shall be a maximum of 6% and each luminaire shall be wired separately.
- H. Final connections to luminaires shall be carried out using silicon rubber sheathed cables.
- I. Where low voltage tungsten halogen lamps are to be dimmed, the dimmer shall be of the hard fired type suitable for inductive loads.
- J. Transformers used in dimmed circuits shall be down rated as recommended by the manufacturer.
- K. Electronic transformers shall be designed to IEC 742 and 34C/Comex (pk) 8 and 14 with RFI suppression to a minimum standard of IEC, DIN/VDE : 0875 and shall comply with the EMC directive.
- L. Electronic transformers shall have short-circuit and overload protection.
- M. Electronic transformers shall contain a soft start circuit and be self-regulating.
- N. Electronic transformers used in dimmed circuits shall be suitable for dimming. The dimmer shall be compatible with the transformer and be recommended by the transformer manufacturer.
- O. When installed in ceiling voids, the transformer shall be properly supported to avoid the transmission of vibrations.

- P. When installed in ceiling voids, the transformer shall be capable of subsequent removal, either through the fitting aperture or through an access panel.
- Q. Transformers shall be located away from high temperature parts of the lamp and luminaire or any other heat radiating surface in the void.
- R. Lamp-holders in dichroic or capsule luminaires shall be easily accessible for re-lamping.
- S. Lamp-holders for tungsten halogen lamps shall be of the best quality with ceramic bases suitable for the currents and temperatures achieved during constant use.
- T. Springs and other metal parts in the lamp-holder assembly shall not deteriorate during use such that poor contact arcing, welding or slackness can occur.
- U. Dichroic and Sealed Low Voltage Tungsten Halogen Lamps :

Where sealed low voltage lamps are used the luminaire shall be designed to cope with the increased temperature.

Where dichroic lamps are used the internal wiring shall cope with the increased temperature.

All dichroic lamps shall be of the captive type and supplied with a GU 5.3 base.
- V. Capsule Low Voltage Lamps

Capsule lamps shall not be installed using bare hands.

Where capsule lamps are used the envelope shall be made of quartz glass.

Where capsule lamps are used a protective glass shall be incorporated into the luminaire design.
- W. Mains Voltage Tungsten Halogen Lamps

Luminaires designed to accommodate double-ended mains voltage tungsten halogen lamps shall be designed to ensure that a minimum bulb wall temperature of 250 °C and a maximum pinch point temperature of 350 °C are achieved.

2.7 FLUORESCENT LUMINAIRES

- A. Unless otherwise stated fluorescent tubes of the size, wattage and colour detailed in the schedules shall be supplied with each luminary.
- B. All cables shall be secured within the luminary body to prevent loose lengths from touching hot surfaces or becoming trapped beneath cover plates. Cable clips or cleats shall be captive and if secured by adhesive, shall not loosen with age.

C. All fluorescent luminaires shall be supplied with high frequency electronic ballast.

The high frequency electronic ballast shall be used for single or two lamps.

The high frequency electronic ballast must have the following features:

- * Components of the ballast shall include:
 - Low pass filter to limit harmonic distortion, radio frequency interference and protect against peaks of main voltage.
 - Rectifier.
 - Buffer capacitor.
 - High frequency oscillator.
 - Lamp stabilization.
- * The operating high frequency should be (24 - 31) KHz,.
- * The ballast shall have its own protection system. The ballast shall be short circuit proof, so short circuit on its output terminals shall not damage the ballast.
- * The ballast shall be capable of operating at main voltage of : 220 V + 10 %.
- * The ballast start should be flicker – free warm start.
- * Maximum temperature value at test point shall not exceed 75 C.
- * Power factor shall be 95 % or more.
- * The ballast should be capable of high switching frequency.
- * The harmonic distortion shall be within the acceptable limits of:
 - IEC 555-2 Specification.
- * "Note: Ballast will be tested and rejected if not complying with the above mentioned specifications".
- * Starting time shall be less or equal 1.5 seconds.
- * Electromagnetic interference shall be within the limits of CISPR 15 regulations.
- * Average service life shall be better than 40000 hours at test temperature of 75 C.
- * The failure rate at 4000 hours operating hours shall not exceed 1.5% at a test temperature of 75C.

D. Wiring within the fixture and for connection to the branch circuit wiring shall not be less than 1.5 mm² for 220 volts application. Insulation shall be silicone rubber for the lower temperatures (fluorescent fixtures) and impregnated asbestos for the higher temperatures.

- E. Aluminum reflectors and louvers shall be made from high purity aluminum (99.9 % minimum) with low or very low iron. The anodic film shall have a minimum thickness of 2.5 microns.
- F. Louvers and reflectors shall be packed separately from the luminary body and protected against damage.

Aluminum louvers shall not be installed until after the building has been thoroughly cleaned prior to practical completion.
- G. Louvers shall not be installed using bare hands. Any louvers found with finger, palm marks or builders dirt and dust shall be removed and cleaned using a high pressure hose with kodak 600 dirt emulsifier or a similar method approved by the louver manufacturer. Louvers shall not be wiped clean.
- H. Diffusers shall be made from UV stabilized acrylic or light stabilized polycarbonate, injection moulded or equal and approved.
- I. The diffusers shall not support combustion and shall be self-extinguishing.
- J. Lamps of different types or ratings shall be controlled from separate dimmers.
- K. Lamps or dimming circuits shall be of the same color temperatures and color appearance. To maintain a constant appearance all lamps on dimming circuits shall be changed at the same time.

2.8 LAMPS

General :

Lamps shall be of wattage and type as shown on the Drawings.

Lamps for final permanent installation shall not be placed in the fixture until so directed by the Engineer and this shall be accomplished directly before the building areas are ready for occupancy by the Employer.

Lamps shall be furnished and installed in all lighting fixtures supplied.

Lamps used for temporary lighting service shall not be used in the final lambing of fixture units.

Fluorescent Lamps :

Lamps shall have bi-pin bases and a minimum approximate rated life of 12,000 hours.

All lamps shall be energy saving type.

Unless otherwise indicated on the Drawings all fluorescent lamps shall have the colour rendering index (84) and equal to "TL" D 36 W (26 mm diameter) and "TL" D 18 W (26 mm diameter).

Incandescent Lamps :

Incandescent lamps 200 watts and below shall be inside frosted type.

Lamps shall be for operation at 220 volts with a minimum approximate rated life of 1000 hours.

Lamps shall have an E.S. screw base for lamps up to 200 watts and a G.E.C. screw base for lamps 300 watts and larger.

2.9 COMPACT FLUORESCENT LAMPS

- A. luminaires containing compact fluorescent lamps shall be designed to ensure the correct working conditions for the lamp.
- B. All compact fluorescent luminaires shall be supplied with high frequency electronic ballast.
- C. All compact fluorescent lamps shall be suitable for operation with high frequency ballasts.
- D. All compact fluorescent lamps shall be energy saving type.

2.10 EMERGENCY LIGHTING SYSTEM

- A. Exit signs shall be manufactured to meet the appropriate requirements of IEC, DIN/VDE standards.
- B. All "Exit" signs and fire safety signs shall be of the pictogram type utilizing the pictograms as given in IEC, DIN/VDE standards. Where wording is incorporated on the signs it shall be in accordance to IEC,DIN/VDE standards.
- C. Sizes of lettering shall comply with IEC, DIN/VDE standards.
- D. Self-energized signs (in respect of luminosity) shall comply with IEC,DIN/VDE standards.
- E. Each sign shall be internally illuminated by two separate systems of lighting.
- F. The housing shall be designed to maintain an internal ambient temperature below that of the lowest temperature rating of any piece of equipment installed therein.
- G. Emergency lighting shall be of centralized control system.

2.11 PARTICULAR REQUIREMENTS

A. GENERAL

The Contractor shall be responsible for ensuring that the design and installation of all lighting complies with CIBSE lighting code LC1 1988 and lighting guide LG3 1989 and with this specification.

All layouts shall be developed in conjunction with the Owner's Authorized Representative.

In general all lighting shall be wired in a minimum of 1.5 mm² single core cables and protected by a 16 A Type 2 or 3 MCB. Larger cable sizes shall be used where necessary to comply with the IEE wiring regulations 16th. edition.

B. PLANT AREAS

All plant areas shall have fluorescent luminaires as specified in the schedules.

The contractor shall ensure luminaires are positioned such that lighting levels are not significantly affected by adjacent services such as pipework or ductwork. Where necessary luminaires shall be installed on chains.

The contractor shall consider the use of plantrooms where required and shown on the drawings (i.e. lift motor room, electrical switchroom, water tank room) before determining the lighting design criteria.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which lighting fixtures are to be installed. Notify in writing of conditions detrimental to proper completion of work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 AIMING AND ADJUSTMENT

- A. All adjustable lighting units shall be aimed, focused, locked, etc., by the Contractor under the supervision of the Lighting Consultant. The Lighting Consultant shall indicate the number of crews required. All aiming and adjusting shall be carried out after the entire installation is complete. All ladders, scaffolds, etc. required shall be furnished by the Contractor at the direction of the Lighting Consultant. As aiming and adjusting is completed, locking set screws and bolts and nuts shall be tightened securely.
- B. Where possible, lighting fixtures shall be focused during normal business hours. However, where daylight interferes with aiming and focusing, this work shall be performed at night at no additional cost to Owner.

3.3 CLEANUP

- A. Furnish all available maintenance data for each lighting fixture to the Owner, including tools required for routine maintenance, types of cleaners to be used, replacement parts lists and for custom or modified custom fixtures, as-built shop drawings.
- B. At the time of final acceptance by the Owner, all lighting fixtures shall have been Thoroughly cleaned with materials and methods recommended by the manufacturers, all broken parts shall have been replaced, and all lamps shall be operative.

3.4 INSTALLATION

- A. Install lighting fixtures as indicated, in accordance with lighting fixture manufacturer's written instructions, requirements of applicable Standards and in accordance with recognized industry practices to insure that installation complies with requirements and fulfills intended function.
- B. Coordinate as necessary to properly interface installation of lighting fixtures with other works.

- C. Install each fixture properly and safely. Furnish and erect hangers, rods, mounting brackets, supports, bases, cables, canopies, channels, frames, and other equipment required.
- D. Furnish lighting fixtures complete with appurtenances required for the proper, safe and distortion-free installation in the various surfaces in which they appear.
- E. Obtain each lighting fixture packaged with complete instructions and illustrations showing how to install. Install lighting fixtures in strict conformance with manufacturer's recommendations and instructions.
- F. Install lighting fixtures plumb and at a height from the floor as specified. In cases where conditions make this impractical, refer to the consultant for a decision. Use ball aligners, hang straights and canopies on pendant fixtures.
- G. Do not install fixtures and/or parts such as finishing plates and trims for recessed fixtures until all plastering and painting that may mark fixtures finish has been completed.
- H. Lighting fixture locations in mechanical and technical rooms is approximate. Coordinate mounting height and location of lighting fixtures to clear equipment and to illuminate equipment adequately.
- I. Support all lighting fixtures independently.
- J. Whenever a fixture or its hanger canopy is applied to a surface mounted outlet box, utilize a finishing ring to conceal the outlet box.
- K. Make splices in internal wiring with approved insulated "wire nut" type mechanical connectors, suitable for the temperature and voltage conditions to which they are subjected.
- L. Use wire suitable for temperature, current, and voltage conditions to which it is subjected where utilized for connections to or between individual lamp sockets and lamp auxiliaries (i.e., wires which do not constitute "through circuit" wiring).
- M. Replace blemished, damaged or unsatisfactory fixtures as directed.
- N. Install all lighting units set true and free of light leaks, warps, dents, and other irregularities.
- O. Install all lighting units free of dust and dirt.
- P. Do not scale electrical drawings for exact location of the lighting fixtures. In general, the approved coordinated reflected ceiling workshop plans shall indicate the proper locations of lighting fixtures.
- Q. Rigidly align continuous rows of lighting fixtures for true in-line appearance.
- R. Do not install recessed fluorescent fixtures weighing more than 18 kilograms directly on a concealed or exposed ceiling spline of a lightweight acoustical ceiling system. Support such fixtures from the building structure.

- S. Do not mount surface or pendant type fluorescent fixtures regardless of their weight directly on the concealed or exposed ceiling spline of a lightweight, acoustical ceiling system. Support such fixtures from the building structure.
- T. Install reflector cones, baffles, aperture plates, light controlling element for air handling fixtures, visible trim, and decorative elements after completion of ceiling tiles, painting and general cleanup.
Carefully handle to avoid scratching or fingerprinting and provide completely clean to the Owner at the time of acceptance.
- U. If required by the ceiling system(s), each recessed and semi-recessed fixture shall be furnished with "mounting frame or ring compatible with the ceiling in which they are to be installed. The frames and rings shall be one piece or constructed with electrically welded butt joints and shall be of sufficient size strength to sustain the weight of the fixture.
- W. Light leaks between ceiling trim of recessed lighting fixtures and the ceiling are acceptable. For fixtures on partially transparent ceilings, light leaks above the ceiling line are not acceptable
- X. Fixtures for use outdoors shall be suitably gasketed to prevent the entrance of moisture. Provide approved wire mesh insect screens for ventilation openings. Install and seal all lighting fixtures and associated equipment used outdoors shall be constructed of materials suitable for the environment in which it is installed: e.g. in a salt air environment, use materials such as copper-free aluminum stainless steel, etc: in a cold environment provide 0° rated fluorescent ballasts, etc.
- Y. All fixtures designed to be recessed in suspended ceilings shall be supplied with pre-wired junction boxes.
- Z. Remote step-down transformers and associated wiring shall be sized to minimize voltage drop at fixture locations. Provide enclosures and acoustically isolated mounts to assure quiet operation. Transformers found by the architect to be unduly noisy shall be replaced without charge prior to acceptance of the job.
- Z1. Temperature on the exterior of fixture housing and auxiliaries shall not exceed 205° C at any point.
- Z2. Provide thickness of metal as indicated in luminaire schedules and details, or as required so that luminaires are rigid, stable and resists deflection, twisting, warping or bending under normal installation procedures. relamping etc., or no less than requirements specified herein the specifications.
- Z3. Provide neoprene or silicone gasketing, barriers and stops where required to prevent light leaks or water/watervapour penetration.
- Z4. Fabricate housings to allow for easy accessibility and replacement of parts.

3.5 FIELD QUALITY CONTROL

- A. Upon completion of installation of lighting fixtures and after building circuitry has been energized, apply electrical energy to demonstrate capability and compliance with requirements. When possible, correct malfunctioning units at the site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.
- B. Certify that the equipment has been properly installed, adjusted, and tested.

END OF SECTION 21

SECTION 22
LIGHTING CONTROL SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions (General requirements), apply to work of this section.
- B. Basic electrical materials and methods, section 16050 applies to work of this section.

1.02 DESCRIPTION OF WORK

The following specifications detail the minimum performance and related criteria for a lighting control system for public areas, corridors, stairs, generic spaces, atriums...etc. Any deviations from this specification must be documented in writing and submitted to the Engineer include but not limited to equipment, equipment installation, power wiring labor and materials, programming and documentation.

Work install and test a lighting control system as specified herein for the areas indicated on the drawings, specifications and load schedule(s).

1.03 SYSTEM DESCRIPTION

System shall consist of factory pre-assembled switching panels, centralized preset lighting control(s), low voltage wallstations and/or control interfaces, and solid-state high frequency fluorescent ballasts. System shall provide local and / or centralized lighting control capability. Additional items may also be required and are described herein and/or shown on the drawings.

1.04 SUBMITTALS

- A. Provide a written line-by-line review of the specification.
- B. Shall include a load schedule which indicates the actual connected load and load type per circuit, circuits and their respective control zones, circuits that are on emergency and the capacity, phase, and corresponding circuit numbers (per the electrical drawings).
- C. Shall include a complete schematic of the system.
- D. Shall include catalog cut sheets with performance specifications including historical testing data demonstrating complete compliance to all of the specifications herein.
- E. Shall include all exceptions taken to the Specification.

- F. Manufacturer shall provide any additional information or factory demonstrations to demonstrate conformance with Part 2 of this specification.
- G. Complete catalogue data, specifications and technical information on alternate equipment must be furnished to the Engineer.

1.05 QUALITY ASSURANCE

- A. Manufacturer shall have a minimum of 10 years continuous experience in the manufacturing of lighting controls.
- B. Lighting control system shall be UL, CSA, NOM or CE listed (where appropriate) specifically for the required loads (i.e. incandescent, magnetic and electronic low voltage, fluorescent, etc.). Manufacturer shall provide evidence of compliance on request.
- C. Manufacturer shall have their quality system registered to the ISO 9001 Quality Standard, including in-house engineering for all product design activities. Due to the exclusion of the Design Control element, ISO 9002 Registration is not acceptable.
- D. Manufacturer shall have component quality program in place to reduce defective levels to less than 100 PPM and provide documentation on request.
- E. Lighting control system shall meet IEC801-2, tested to withstand a 15kV electrostatic discharge without damage or loss of memory.
- F. Manufacturer shall provide software to simplify the design and installation of all lighting controls.
- G. Lighting control system shall be bid separately from all other lighting equipment. Packages of lighting equipment and dimming systems shall not be acceptable.

1.06 PROJECT/SITE CONDITIONS

Lighting controls shall operate in an ambient temperature range of 0°C (32°F) to 40°C (104°F) and 90% non-condensing relative humidity without the requirement of a regularly scheduled maintenance program for air filtration components.

1.07 WARRANTY

The manufacturer shall provide a full one-year limited warranty on all equipment supplied. The warranty shall cover 100% of the parts and manufacturers labor costs required over the first two-years, which are directly attributable to the manufacturer. The factory commissioned warranty shall also entitle the end user to an eight-year replacement parts program. Warranty coverage shall begin on the date that the equipment is energized.

1.08 COMMISSIONING

- A. A factory-employed engineer shall make a minimum of three site visits to ensure

proper system installation and operation. The first visit shall consist of a prewire inspection. Upon completion of the installation, the system shall be completely commissioned by a factory-employed engineer. The check-out will be performed after all loads have been tested live for continuity and freedom from defects and that all control wiring has been connected and checked for proper continuity. During the third visit, a factory-employed engineer shall demonstrate and educate the owner's representative(s) on the system capabilities, operation and maintenance.

1.09 MAINTENANCE

- A. The manufacturer shall make available to the end user a method of ordering new equipment for expansions, replacement, or parts to be used as spares twenty-four hours a day, seven days a week. The manufacturer must make available new or remanufactured parts for a minimum period of ten years from the final date of commissioning.
- B. The manufacturer shall supply factory service, new or remanufactured replacement parts, and a service contract that extends the factory-limited warranty from two to five years. In addition, this shall allow end user to purchase this coverage on an annual basis for a minimum period of ten years from the date of final commissioning.

PART 2 - PRODUCTS

2.01 SWITCHING PANEL

A. Mechanical

- 1. Panels shall be UL listed, CSA certified, NOM approved, or CE marked (as appropriate).
- 2. Panels shall be wall or recess mountable. Enclosure shall be NEMA Type 1 and IP-42 rated as specified by IEC 60529. Panel shall be constructed of steel with steel gauge of type required by UL508. Contractor shall reinforce wall as required.
- 3. Panels shall be completely pre-assembled and factory tested by the manufacturer prior to shipment. The contractor shall be required to provide input feed wiring, load wiring, and control wiring. No other wiring or assembly by the contractor shall be permitted. Panels requiring field assembly are not acceptable.
- 4. All input feed, load, and control terminals shall be front accessible without the need to remove switching assemblies or other components.
- 5. Panels shall be passively cooled via free-convection, unaided by fans. Systems that are fan dependent or fan assisted for cooling of components are not acceptable. Systems that require or recommend regularly scheduled maintenance for air filtration components are not acceptable.

B. Electrical

1. Panel shall contain switching modules. Each module shall contain four switched outputs. Each output may be controlled independently or in combination with any other output within the panel or with outputs from other panels within the system.
2. Unless the panel is a dedicated feed-through-type panel or otherwise indicated, panels shall contain branch circuit protection for each switched output.
3. Branch Circuit Breakers in 220-240 Volt Panels shall have the following performance characteristics
 - a. Branch circuit breakers used in residential applications shall be certified to meet the IEC 60898 standard. When used in commercial applications, the branch circuit breakers shall be certified to meet the IEC 60947 standard.
 - b. Shall be rated at 25,000 without the need for additional externally mounted equipment.
 - c. Be thermal-magnetic in construction for overload, short-circuit, and over-temperature protection. The use of fully magnetic breakers shall not be acceptable.
 - d. Be replaceable without moving switching assemblies or other components of the panel.
4. Panel should have minimum UL listed short circuit current rating (SCCR) of 42,000A.
5. Panels shall be equipped with an electronic module BYPASS feature which electronically switches outputs to ON by toggling the individual branch circuit breakers (for individual circuits) or main breaker (for all circuits) when there is no data available from the control system.
6. Panels shall be shipped with each output in a mechanical BYPASS position via a jumper bar inserted between the input and load terminals to allow panel to be used as a temporary lighting panel with no possibility of switched output failure due to short-circuit condition. These jumpers shall carry the full-rated load current and shall be reusable at any time. Mechanical bypass device must allow for switching operation of connected load with the module removed via a circuit breaker. Bypass devices that are integral to the switching module are not acceptable.
7. Panel shall be capable of operating from a normal feed, an emergency feed, or a normal/emergency feed. Panels requiring additional devices to make them capable of accepting normal/emergency or emergency feeds are not acceptable.
 - a. Normal / Emergency Panels
 - i. Upon the loss of normal input power, a panel operating from a normal / emergency feed shall immediately turn all circuits within that panel to full-on condition when emergency input power is present.
 - ii. During the presence of normal power, circuits designated as emergency circuits shall be controlled via the same controls as circuits designated normal. If both normal and emergency circuits are on the same zone of control, all circuits shall react identically to a control intensity change.

- iii. Emergency power feed may be provided by an emergency generator, a UPS system, or an IPS system with true sine wave output and a maximum of 10% THD when driving dimmed loads. The generator, UPS system, or IPS system must be capable of operating under no load conditions. Alternatively, the generator can be turned on only under emergency conditions.
- iv. Normal / Emergency panels shall be fed by a single Normal / Emergency feed through the use of a line side (upstream) normal/emergency power transfer switch supplied by others.
- v. Under Emergency input power feed, unless otherwise indicated all dimmers shall operate at 100% of dimmer output voltage. Under these conditions, semiconductor device will be in the full-on state.
- vi. Under Emergency input power feed, if required, dimmer shall be capable of operating lighting load at an emergency level lower than 100% dimmer output voltage. Panels shall provide means to modify this emergency output level via panel processor without requiring external programming devices.
- vii. Under Emergency input power feed, all local control stations shall be inoperable. Once normal power is restored, all lighting zones shall revert back to their status prior to the emergency condition without requiring any action on the part of the user. Restoration to OFF, ON, or a "default" level is not acceptable.

b. **Emergency Panels**

- i. Upon the loss of normal input power, a panel operating from an emergency feed shall immediately turn all circuits within that panel to full-on condition when emergency input power is present.
- ii. Emergency power feed may be provided by an emergency generator, a UPS system, or an IPS system with true sine wave output and a maximum of 10% THD when driving dimmed loads. The generator, UPS system, or IPS system must be capable of operating under no load conditions. Alternatively, the generator can be turned on only under emergency conditions.
- iii. Under Emergency input power feed, if required, switched output shall be capable of turning lighting OFF. Panels shall provide means to modify this emergency output state via panel processor without requiring external programming devices.
- iv. Under Emergency input power feed, all local control stations shall be inoperable. Once normal power is restored, all lighting zones shall revert back to their status prior to the emergency condition without requiring any action on the part of the user. Restoration to a "default" state is not acceptable.

C. Switching Module

- 1. Under fully-loaded operating conditions, all semiconductor devices shall operate at a minimum 20°C (36°F) safety margin below the component manufacturer's maximum component temperature rating at a 40°C (104°F) ambient room temperature.

2. A positive air gap switch shall be employed by each switched output in the panel to ensure that the load circuits are open when the "off" function is selected from the control system.
3. Switched output shall be capable of withstanding inrush current of 75 times operating current typically generated by a full circuit of switching electronic non- dim ballasts.
4. Once installed as part of a complete system, the relays used to control the power furnished to the loads shall be both designed and tested to withstand surges, without impairment to performance, of 6000V, 3000A (equivalent to a near lightning strike) as specified by ANSI/IEEE std. C62.41. Upon request, the manufacturer shall provide a means to demonstrate conformance to this specification using the appropriate surge-generation equipment.
5. Each switched output shall be rated for 16A continuous duty for the following load types: resistive (incandescent/tungsten), inductive (magnetic low voltage (MLV), electronic low voltage (ELV), neon/cold cathode, magnetic & electronic fluorescent lamp ballasts, high intensity discharge (HID)). Motor Loads (1/3HP at 220V, 1/2Hp at 220 or 380V). Relays rated only for resistive loads shall not be acceptable.
6. Load shall be switched in a manner that ensures no arcing will occur at the mechanical contacts when power is applied to the load circuits.
7. Average rated life of relay shall be at least 1,000,000 cycles

D. Panel Processor

1. Panel processor shall provide the following programming capability:
 - a. Electronically assign each circuit to any zone in the system.
 - b. Determine Normal / Emergency function of panel and set emergency lighting states.
2. Panel processors using mechanical switches, rewiring, or EPROMS for reprogramming circuit-to-zone assignments and other functions shall not be acceptable. Panels requiring the use of proprietary software without the capability to program circuit-to-zone assignments and other functions manually shall not be acceptable.
3. All circuits shall be capable of being operated from the panel processor.
4. Panel processor shall maintain switched outputs at current state (ON or OFF) in the event of a control failure. Systems that fail to a set state (OFF or ON) during a control failure are not acceptable.
5. Panel processor shall be capable of operating by control systems utilizing an approved software protocols.

6. Panel processor shall react to changes from the control in no more than 20 milliseconds (Update rate of 50 times per second).

E. Maintenance and Diagnostics

1. Replacing a switching modules shall not require re-programming of the system or processor.
2. Switching modules shall include diagnostic LEDs to verify proper operation and assist in any system troubleshooting.
 - a. Under normal operation, LED indicator shall flash approximately once every second.
 - b. If there is no control data being received from the panel processor to the dimmer, LED indicator shall flash approximately once every 8 seconds.
3. Switching modules shall provide selector switch to test individual circuit operation for fault detection. Three tests are available:
 - a. Individual Module Output Test (100% on each module)
 - b. All modules Output Test (100% on all modules)
 - c. Shorted Semiconductor Test

2.02 SYSTEM SOFTWARE

- A. System operation shall be via the centralized lighting server.
- B. The lighting Server shall be network compatible via LAN (Local Area Network).
- C. Lighting Control System must incorporate 10baseT Ethernet integration supporting TCP/IP communication protocols integral to the lighting server. Data distribution on the lighting control system network shall be layer 3 routable over the network.
- D. System Set-up shall provide the following functions and capabilities:
 1. Create nested spaces that accurately represent the space
 2. Add control stations and control station devices to spaces
 3. Add zones to spaces
 4. Assign switch legs to zones
 5. Create groups
 - a. Groups may contain any Controllable Object - Zones, Spaces, Control Stations or Switch Legs in any combination.
 - b. Zones, Spaces, Control Stations and Switch legs may be included in one or more groups.
 6. Create modes
 - a. Modes are applied to groups

- b. Modes contain preset values for every Controllable Object
 - c. Values for Controllable Objects may be set to produce No Effect on the object or User Control for Objects with Local Controls.
- 7. Create monitors and controls
- 8. Assign switch legs to control station devices
- 9. Assign switch legs to dimming cards/remote power modules
- 10. Program controls station devices
- 11. Add panels to spaces
- 12. Create partitionable spaces
 - a. Scene chaining
 - b. Conditionals
- 13. Create time-clock schedules
 - a. Single Event
 - b. Periodic
- 14. Gang control station devices in control station
- 15. Create scenes
- 16. Compile and transfer database to processor
- E. Software must allow for a CAD-based Graphical user interface to allow for graphical navigation. Each screen shall be related in a hierarchical manner so that the operator shall be able to navigate from a general lighting plan to a specific area.
 - 1. The Floor plan's Top Level graphic provides an overview of all building areas beginning with an overview of the entire facility and proceeding to successively more detailed views of individual areas for precise control of the system.
 - 2. The customer must supply each floor plan graphic 8 weeks prior to software ship-date (in an SVG (preferred), AI, BMP, DWG, DXF, EMF, GIF, JPG, or WMF format).
 - 3. Customer shall define specific functions required to be available via CAD Graphical screens from the list of functions listed in operate software capabilities no later than 8 weeks prior to software ship-date.
- F. The lighting control system shall be capable of responding to the following:
 - 1. Control Station Devices
 - 2. Web-based Graphical User Interface (GUI) commands
 - 3. Contact-closures
 - 4. RS-232 Command Strings
 - 5. BACnet IP commands
- G. An integral timeclock shall allow for selection of preset scenes and locking or unlocking control stations. Commands can be in either real or astronomic (relating to sunrise/sunset) time. Timeclock shall automatically correct for daylight savings time and leap year where appropriate. There shall be a total of 10 timeclock schedules available per room or area (one per day of each week, plus three special schedules).

Any special schedules that have been programmed shall be capable of being stored in a "calendar" format on a screen up to a year in advance. The timeclock shall be capable of executing up to 60 events per day. The timeclock can be enabled or disabled for any area via either the system operate software or local accessory control.

- H. An integral partitionable space wizard shall allow on-screen control definition of partitionable spaces. Template shall allow user to define if room is independent or combined with adjacent room(s) and lockout/unlock control stations.
- I. Software shall allow the building's software administrator to assign users. Administrator shall also be able to assign specific usernames for individuals. The software shall also allow the administrator to select the language of the users. Multiple languages must be supported on the same system. System shall support at least:
 - 1. English
 - 2. Arabic
- J. System Reliability
 - 1. In the event of a control station failure or interruption of a communication line to any of the controls, the lights controlled by those stations shall remain at their current levels.
 - 2. The control system processor shall have a full internal battery backup that can store all system memory for 1 year without power.
 - 3. All local controls and dimmer and/or relay panels shall also have power-failure memory.
 - 4. It shall not be necessary to re-boot the system manually nor use any tape or floppy disk/hard drive to restore the system once power has been restored - system shall automatically return to its previous state.
 - 5. The main processor shall be protected by an integral isolation transformer and shall meet the ANSI/IEEE specification for transient protection (Ref. 2.03 P).
- K. Lighting Control System must incorporate voice-prompted telephone interface to allow for the following commands:
 - 1. Adjust a Zone Level
 - 2. Select a Scene
 - 3. Select a Group/Mode Combination
- L. Lighting Control System must allow for inter-processor communication.

2.03 CENTRALIZED PRESET LIGHTING CONTROL PROCESSOR

- A. Definitions: A "scene" or "preset" is a specific look or mood created by different lighting zones set at different intensities. A "zone" is one or more lighting circuits which are controlled together as a group.
- B. Control shall provide power failure memory. Should power be interrupted and

subsequently returned, the lights will come back on to the same levels set prior to the power interruption without requiring any actions on the part of the user. Restoration to some other default level is not acceptable, unless specifically noted elsewhere.

- C. Wiring from dimming and switching panel(s) to centralized preset lighting control and wallstations, preset local lighting controls, and control interfaces shall be low voltage type Class 2 wiring (PELV).
- D. Where indicated on the drawings, control shall provide preset lighting scenes for up to 512 zones—expandable to 16,384 zones when using multiple control processors—in any combination of groups or areas.
- E. Control shall allow design of system off site and downloading upon installation or modifications after installation.
- F. Control shall also be capable of interfacing to other equipment via integral RS232 interface and/or modem (by others). Additional interfacing shall be available via RS232 wallstations.
- G. Control shall be capable of operating with up to 192 wallstations, preset local lighting controls, and control interfaces—expandable to 6,144 when using multiple processors. Where indicated on drawings, use wallstations, preset local lighting controls, and control interfaces as required.
- H. Connect up to 32 processors together using TCP/IP over 10/100 BaseT Ethernet or RS485 over twisted, shielded pair.
- I. An integral timeclock shall execute any of the following events: select preset scenes, lockout control stations, or unlock control stations. Commands can be in either real astronomic (relating to sunrise/sunset) or reference time. Timeclock shall automatically correct for daylight savings time and leap year where appropriate based on user entered location. There shall be a total of 10 timeclock schedules available per space (one per day of each week, plus three special schedules). Any special schedules shall be capable of being stored in a "calendar" format on a screen up to a year in advance for easy reference. The timeclock shall be capable of executing up to 600 events per day. The timeclock can be enabled or disabled for any area via either the operate software computer or local wallstation/control interface.
- J. An integral partitionable space wizard shall allow on-screen control definition of partitionable spaces. The wizard shall allow user to define if room is independent or combined with adjacent room(s) and to delete and lockout/unlock control stations.
- K. In the event that any of the communication lines to any of the dimmer and/or switching panels is interrupted for any reason, the lights controlled by those panels shall remain at their current levels until the interruption is cleared. In the event of a control station failure or interruption of a communication line to any of the controls, the lights controlled by those stations shall remain at their current levels.
- L. The complete control system shall have a full internal battery backup that can store all system memory for 1 year without power. It shall not be necessary to re-boot the system manually nor use any tape or floppy disc/hard drive to restore the system once

power has been restored—system shall automatically return to its previous state.

- M. The processor shall interface with a PC via an RS232 to RS485 adapter. The PC shall be located within 50 feet of the adapter jack.
- N. The processor shall be capable of controlling Sivoia Motorized Window Enhancement and AC Shade load types. AC Shade zones shall be capable of three settings in a preset scene: Fully Open, Fully Closed, and Unaffected. Sivoia shade zones shall be capable of recalling up to 5 preset shade positions in a preset scene. (Integrated control of Sivoia Motorized Window Enhancements will be available 1/5/04).

2.04 LCD-Based Lighting Control Wallstation (LCP)

- A. LCD-based wallstations shall be provided as indicated on drawings and / or directed by the Engineer.
- B. Control must be capable of accepting software enhancements without the need for hardware modifications
- C. LCD screen must provide 320x240 pixels of resolution. Contrast and backlight brightness must be adjustable.
- D. Control must automatically configure itself upon installation with all building zone names, scene names, area names, scene intensities, fade times, delay times, and timeclock status from preprogrammed information from system processor.
 - 1. Control will display zone names, scene names, and area names in English, French, Spanish, Dutch, German, Italian, or Portuguese if user enters this information into the processor.
 - 2. Control menus and help screens can be displayed in English, French, Spanish, Dutch, German, Italian, or Portuguese.
- E. Control must be capable of accessing every area, scene, and zone within the associated architectural lighting control processor. Controller must allow user to:
 - 1. View and modify the scene status of an area.
 - 2. Temporarily modify zone intensities in an area.
 - 3. View timeclock status for all areas.
 - 4. Enable or disable timeclock for an area.
 - 5. Permanently modify zone intensities, zone delay times, and zone fade times in an area via online or offline programming. Scene programming must be accomplished without the use of an "enter" or "store" button. Programming may be accomplished either online or offline.
 - a. Online programming – Allows scene programming via real-time adjustment of lighting zones. Lighting levels change during on-line programming
 - b. Offline programming – Allows for scene adjustments that are previewed via numeric intensities and bargraphs. Lights in space shall not change during off-line programming

- F. If power to lighting control system is lost, LCD-based control must automatically update when power is restored. Light levels in area where power to system processor is lost shall not change or turn off as a result.
- G. Control shall have several configuration options for each area. Each option limits user access to the system. Each area shall be configurable to any of the following access levels from the control:
 - 1. Hidden (can not be selected for the control's default area)
 - 2. Monitor only
 - 3. Change scenes
 - 4. Programmable
- H. Control programming and setup configuration may be restricted via user-modifiable numeric passcode.

2.05 HANDHELD PROGRAMMERS AND JACKS

A. Handheld Programmer

Handheld programmer shall be provided at each floor of the building (or as indicated in the drawings) and shall provide the ability to change intensity and fade time for each zone in the lighting control system without the use of a PC. Unit shall allow access to all areas, scenes, and zones in the system. Unit shall provide current light level indication and a thumbwheel for light level adjustment. Unit shall have a zone finder button for easy identification of the zone being programmed. Unit shall be equipped with a 25' (76.2m) cord.

B. Handheld Programmer Jack

Handheld programmer jack shall provide access to local programming of the lighting control system from hand-held programmers.

2.06 WALLSTATIONS

- A. Faceplate shall attach using no visible means of attachment.
- B. Wallstations shall be engraved with appropriate zone and/or scene descriptions, furnished to the manufacturer prior to fabrication. Size and style of engraving type shall be determined by the Architect. Any silk-screened borders, logos, graduations, etc. shall use a graphic process that chemically bonds the graphics to the metal faceplate, resisting removal by scratching, cleaning, etc.
- C. Manufacturer shall ensure the following items regarding product color:
 - 1. Product color matches NEMA standard WD1, Section 2, and the maximum color deviation from this standard shall not exceed $E=1$, CIE L^*a^*b color space units. For non-NEMA colors, color match coordination shall be provided on request.
 - 2. Color variation of any control in the same product family shall not exceed $E=1$,

- CIE L*a*b color units.
3. Visible parts shall exhibit ultraviolet color stability when tested with multiple actinic light sources as defined in ASTM D4674-89. Manufacturer to submit proof of testing upon request.
- D. Wallstations shall mount individually in standard single gang U.S. wallboxes.
 - E. Wallstation(s) shall provide an immediate local LED response upon button activation to indicate that a system command has been requested. LED will remain lit contingent upon receiving system confirmation of the successful completion of the command.
 - F. Wallstation(s) functions shall be configured through software.
 - G. Single Button Wallstation(s) shall provide one button to toggle between 'Scene 1' and 'off'. Control shall be line voltage.
 - H. Two Button Wallstation(s) shall be capable of performing any of the following functions:
 1. Recalling Scene 1 and 'off,' Scene 9 and 10, or Scene 13 and 14
 2. Directing preset control units to operate independently or in combination to reflect partition status for one moveable wall (two rooms)
 3. Locking out manual control of preset control unit(s) and turning lighting to full 'on' for Panic mode
 4. Sequencing through twelve steps. A sequence shall be defined as a series of steps, while a step shall be defined as the recall of a scene. Each step interval is adjustable for 1 second to 60 minutes.
 5. Fine-tuning an individual zone(s).
 - I. Control shall configured in the field through DIP switches to perform one of these functions. The buttons shall provide green LED status feedback.
 - J. Four Button Wallstation(s) shall be capable of recalling preset light levels for four scenes, each providing green LED status feedback. Control shall be capable of recalling one of four different banks of scenes, which can be configured in the field through DIP switches.
 - K. Four Button Master Wallstation(s) shall provide four buttons which toggle selected preset control unit(s) on to Scene 1 and 'off', each providing green LED status feedback, plus 'ALL ON' -or- 'ALL OFF' for selected preset control unit(s).
 - L. Four Button Partitioning Control(s) shall provide four buttons each capable of directing preset control units to operate independently or in combination to reflect partition status for one moveable wall. Control shall be capable of directing preset control units for up to four moveable walls (five rooms). Each button shall provide green LED status feedback to indicate status of a specific partition.
 - M. Five Button Wallstation(s) with Raise/Lower shall be capable of recalling preset light levels for four scenes, each providing green LED status feedback, plus 'off' and of fine-tuning light levels with master raise/lower. Control shall be capable of recalling one of four different banks of scenes, which can be configured in the field through DIP

switches.

- N. Five Button Wallstation(s) with Raise/Lower and Infrared Receiver shall be capable of recalling preset light levels for four scenes, each providing green LED status feedback, plus 'off'. Control shall provide means for Four Scene Wireless Remote Control(s) and Eight Scene Wireless Remote Control(s) to recall preset light levels for up to four or eight scenes (dependent on wireless remote control) plus 'off' and of fine-tuning light levels. Control shall provide means for wireless remote controls to recall one or two (dependent on wireless remote control) of four different banks of scenes which can be configured in the field through DIP switches.
- O. Five Button Wallstation(s) with Raise/Lower, Infrared Receiver, and Switch Input shall be capable of recalling preset light levels for four scenes, each providing green LED status feedback, plus 'off' from the keypad and from a wireless remote control. Fine-tuning of light levels with the master raise/lower shall be available from the wireless remote control. Control shall be capable of recalling one of two different banks of scenes based on the status of an external dry contact closure wired into the control.

2.07 PRESET CONTROL UNITS

- A. Control shall provide 4 preset lighting scenes and 'off' for up to 24 control zones. Control shall be capable of storing an additional 12 preset lighting scenes which can be accessed via wallstations and/or control interfaces. Preset shall be set via easy-to-use raise/lower switches, one raise and lower switch per zone. The intensity for each zone shall be indicated via an illuminated bargraph, one bargraph per zone. More than one zone may be proportionately raised or lowered at the same time. Programming of preset scenes shall be accomplished without the use of an 'enter' or 'store' button. Additionally, one or more zones may be temporarily overridden without altering the scene values which are stored in memory.
- B. Lighting levels shall fade smoothly between scenes at time intervals of 0 to 59 seconds or 1 to 60 minutes. The fade time shall be separately selectable for each scene and shall be indicated by a digital display for the current scene. Pressing a scene select button will illuminate the corresponding scene LED and simultaneously begin changing the bargraph levels to reflect the currently selected scene. In the event that a preset scene with a fade time greater than 5 seconds is initially selected from an 'off' condition, the programmed fade time shall be temporarily overridden, unless otherwise noted, and the lights shall fade up to that scene over a five-second time span.
- C. Control shall be capable of being set locally, through a handheld programmer, and/or through a PC.
- D. Controls shall incorporate built-in wide angle infrared receiver, providing control via a separate wireless remote control transmitter from up to 50 feet away.
- E. Control shall provide tamperproof protection of scenes using a minimum of four levels of electronic 'lockout' which prevent alterations of scene values stored in memory. Highest level of 'lockout' shall be capable of disabling manual control at the preset control unit.

- F. Faceplate shall attach using no visible means of attachment.
- G. Controls shall be engraved with appropriate zone and/or scene descriptions, furnished to the manufacturer prior to fabrication. Size and style of engraving type shall be determined by the Architect. Any silk-screened borders, logos, graduations, etc., shall use a graphic process that chemically bonds the graphics to the metal faceplate, resisting removal by scratching, cleaning, etc..
- H. Manufacturer shall ensure the following items regarding product color:
 - 1. Product color matches NEMA standard WD1, Section 2, and the maximum color deviation from this standard shall not exceed $E=1$, CIE L^*a^*b color space units. For non-NEMA colors, color match coordination shall be provided on request.
 - 2. Color variation of any control in the same product family shall not exceed $E=1$, CIE L^*a^*b color units.
 - 3. Visible parts shall exhibit ultraviolet color stability when tested with multiple actinic light sources as defined in ASTM D4674-89. Manufacturer to submit proof of testing upon request.
- I. Controls shall provide an immediate, local LED response upon button activation to indicate that a system command action has been requested. LED will remain lit contingent upon receiving system confirmation of the successful completion of the command.

2.08 TAMPER PROOF COVERS

- A. Locking cover shall be available in 1, 2, 3 and 4 gang sizes to accommodate preset control units and wallstations.
- B. Locking covers shall be reversible to allow for locking on either side of the control.
- C. Locking covers shall be compatible with IR controls and shall not reduce the specified IR range by more than 50% of its original specification.

2.09 CONTROL INTERFACES

RS232 Interface(s)

Control shall provide the ability to communicate via RS232 serial communication to the centralized lighting system via a user supplied PC or digital audiovisual equipment. Control must be located within 50 feet (15 meters) of the RS232 source. Control shall provide access to:

- 1. Scene selections
- 2. Fade zone to level
- 3. Ability to flash/warn/chase zone levels
- 4. Fine-tuning of preset levels with scene raise/lower
- 5. Fine-tuning of light levels with individual zone raise/lower
- 6. Enable/disable timeclock

7. Setting of timeclock
8. Enable/disable wallstation
9. Simulate wallstation button press
10. Reading/setting of system variables
11. Control shall provide status monitoring through button feedback and scene-status updates.

2.010 POWER AND DATA REPEATER

- A. Each power and data repeater shall increase the wallstation or panel communication link distance limitation by 2000 feet.
- B. Each link can use up to 3 power and data repeaters, for a maximum distance of 8000 feet.

2.011 SOURCE QUALITY CONTROL

Equipment shall be 100% tested for proper operation at three different levels—printed circuit board, end of line, and for two hours at 40°C (104°F) ambient—prior to shipment from the factory. Manufacturers sampling at end-of-line shall not be acceptable.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Equipment shall be installed utilizing manufacturer's catalogue cut sheets and installation instructions and in accordance with these specifications.
- B. Contractor shall furnish all equipment, labor, system setup and other services necessary for the proper installation of the products/system as indicated on the drawings and specified herein. System setup shall include defining each modules load type, assigning each load to a zone and setting the control functions.

END OF SECTION 22

SECTION 23

EMERGENCY DIESEL GENERATOR PLANT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions "General requirements", apply to work of this Section.
- B. General Provisions for Electrical Work, Section 16050, applies to work of this Section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services and tests necessary to complete and make ready for operation, a diesel engine generator set complete with engine generator batteries, charger, silencer, day tank, generator control panel and all required appurtenances and accessories. Refer to appropriate section of Specifications and drawings for additional requirements.

1.3 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in the manufacture of diesel engine generator sets of the types and capacities required, whose products have been in satisfactory use in similar service for not less than 10 years. Provide diesel engine generator set produced by a manufacturer listed as an Acceptable Manufacturer in this section.
- B. Standards Compliance: Comply with requirements of applicable local codes, IEC, IEEE Standards pertaining to diesel generator set.
- C. NFPA Compliance: Comply with applicable requirements of NFPA 37, "Installation and Use of Stationary Combustion Engines and Gas Turbines;" NFPA 99, "Standard for Health Care Facilities;" NFPA 101, "Code for Safety to Life from Fire in Buildings and Structures;" "Life Safety Code;" "NFPA 110;" and "Emergency Power Systems".
- D. Service: Manufacturer must have a factory warehouse located within 50 Km of the job site, at which spare parts are stocked and where a field service engineer who is a full-time employee of the manufacturer permanently resides, and is a factory trained and qualified individual whose primary duty is field service.
- E. Equipment Rating: 220/380 volt, 3 phase, 50 hz, 1500 rpm, KW rating as indicated on the drawings. At temperature 50 °C and altitude 1500 m humidity 90%. at 0.8 power factor and capable of continuous operation at rated output for the duration of any utility power failure up to 24 hours.
- F. Ratings of diesel electric set based on operation of the set at rated generator RPM when equipped with all necessary operating accessories, such as air cleaners, radiator fan, lubricating oil pump, fuel transfer pump, fuel injection pump, jacket water pump, governor alternating current generator and exciter. All ratings must be factory certified.

- G. The same manufacturer is to build, test, and ship the whole system (the engine, generator, and all major items of auxiliary equipment).

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's data for diesel engine driven generator sets and components, including:
 - 1. Drawing of the diesel generator set.
 - 2. The following data in tabulated form:
 - a. Make of engine.
 - b. Number of cylinders.
 - c. Bore, inches (millimeters).
 - d. Stroke, inches (millimeters).
 - e. Piston displacement, cubic inches (liters).
 - f. Piston speed, feet per minute (liters/min.), at rated RPM.
 - g. BMEP at rated KW output.
 - h. Make and type of generator.
 - i. Generator electrical rating, KVA or KW at .8 power factor.
 - j. Number and type of bearings.
 - k. Exciter type.
 - l. Generator insulation class and temperature rise.
 - m. Parts and service support.
 - n. Engine manufacturer's certified engine BHP curve and certified generator set fuel consumption curve.
 - 3. Batteries and battery charger.
 - 4. Silencer.
 - 5. Fuel system complete including bulk storage-day tank pipes and pumps.
 - 6. Cooling system complete.
 - 7. Exhaust system complete.
 - 8. remote annunciator panel in the fire command center
 - 9. All auxiliaries.

- B. Shop Drawings: Submit dimensional layout on architectural background drawings of diesel engine generator sets.
- C. Submit a certified test report showing serial number of the engine, generator and all accessories furnished, and actual readings taken during a factory-conducted full load test including the following:
 - 1. Cold start acceleration to rated voltage and frequency within 8 seconds.
 - 2. Full and partial load applications and rejections during the test (at least 2 per hour). Frequency and voltage stability and transients not to exceed the limits specified herein.
 - 3. 15 minutes 1/4 load, or function warm up, 1/2 hour 1/2 load, 1/2 hour 3/4 load, and 2 hours full load; plus 2 hours overload at 110%. Test shall be conducted at .8 power factor.
 - 4. Demonstrate that all applicable safety shutdowns function along with their respective audio and visual alarms.
- D. Ten working days written notice shall be given prior to factory tests being carried out and all necessary facilities shall be made available for the consultant to witness such tests.
- E. A complete set of tools and portable instruments for the operation and equipment shall be provided, together with suitable means of identification, storage and securing.

1.5 SEQUENCING AND SCHEDULING DELIVERY, STORAGE, AND HANDLING

- A. Obtain all necessary permits prior to delivery.
- B. Delivery and rigging shall be fully coordinated with, and approved by the consultant.
- C. Upon delivery, inspect for physical damage and compare nameplate rating of unit with this specification.
- D. Prior to installation, engine-generator controls and all associated electrical equipment shall be stored indoors, fully protected from weather, dust and dirt.
- E. Extreme care shall be exercised to prevent bumping or dropping. All rigging and handling shall be in full accordance with engine-generator manufacturers' requirements.
- F. Avoid the use of excessive hammering and jarring which would damage the electrical equipment contained therein.
- G. Do not install damaged equipment, remove from site and replace with new equipment.
- H. Extreme care shall be taken to assure that all equipment is properly secured and braced for any overland and vertical travel.

1.6 EQUIPMENT WARRANTY

- A. Guarantee equipment furnished under these specifications against defective parts and workmanship under terms of the manufacturer's and dealer's standard warranties for a period of not less than 1 year from date of initial start-up and Owner acceptance of the system and include labor and travel time for necessary repairs at the job site. The system warranty not to be limited by running hours.

1.7 SYSTEM SERVICE CONTRACT

- A. The supplier of the diesel engine generator set to provide a service contract for a period of five years after guarantee period and include, but not be limited to, the following:

- 1. Engine manufacturer's recommended procedures for weekly (biweekly) inspection and maintenance to be done by user.
- 2. Quarterly inspection by the supplier personnel to review the weekly maintenance records being kept by user and train any new Owner operating personnel. Inspection to include scheduled oil sampling for lube oil contaminants as outlined below. Also include a 100% load test run on the generator set.
- 3. Annual inspections to include all of items in above paragraph except run the generator set under system load.

- B. Scheduled Oil Sampling

- 1. In order to forecast and minimize engine downtime, the supplier of the equipment must provide an oil sampling analysis kit which operating personnel can utilize for Schedule Oil Sampling.
- 2. Scheduled Oil Sampling of the atomic absorption spectrophotometer method and accurate to within a fraction of one part per million for the following elements:
 - a. Iron
 - b. Chromium
 - c. Copper
 - d. Aluminum
 - e. Silicon
 - f. Lead
- 3. In addition, test the sample for the presence of water, fuel dilution, and antifreeze.
- 4. Provide all equipment needed to take oil samples in a kit at the time of acceptance and include the following:
 - a. Sample extraction gun (1).
 - b. Bottles (10).
 - c. Postage-paid mailers (10).
 - d. Written instructions (1).
- 5. Provide immediate notification to the consultant when analysis shows any critical reading. If readings are normal, provide a report showing that the equipment is operating within established parameters.

PART 2 - PRODUCTS

2.1 RECOMMENDED MANUFACTURER

Refer to list of recommended manufacturers.

2.2 GENERAL

The Contractor shall supply, install and commission the automatic start diesel generating set with all necessary switchgear, control panel and accessories all as either herein specified or shown on the Drawings.

The size of the set shall be provided to the rating shown of the Drawings, when operating at the specified frequency, voltage, altitude, maximum temperature and humidity.

The Contractor shall be guided by the emergency power room layout details shown on the drawings, but a final detailed and dimensioned layout suitable for construction shall be submitted to the Engineer for approval, prior to ordering of equipment.

The Contractor shall indicate the nearest location from which service facilities and spare parts may be obtained.

The design of the plant and its installation including all ancillary equipment, shall be such as to minimize noise and vibration.

Materials and workmanship - All materials, equipment, and parts comprising the units specified herein, shall be new and unused, of current manufacture and highest grade.

Manufacturer - The unit shall be factory assembled, and tested as complete unit by the engine manufacturer. It shall be inspected and started at the job site by his authorized dealer having a parts and service facility in the area.

Warranty - Equipment furnished under this section shall be guaranteed against defective parts or workmanship under dealer's standard warranty. Warranty period shall in no case be less than one year of unrestricted service commencing from date of putting the unit into service and not limited to any fours limitation.

Tests - The generator set shall receive the manufacturer's standard factory load testing. Prior to acceptance of the installation, equipment shall be tested to show it is free of any defects and be subjected to full load test.

Start-up and Instructions - On completion of the installation, start-up shall be performed by a factory-trained dealer service representative. Operating and maintenance instruction books shall be supplied upon delivery of the unit and procedures explained to operating personnel.

Specifications and Drawings - The bidders shall furnish information showing manufacturer's model numbers, dimensions and weights for the generator set and major auxiliary equipment. Proposed deviations from the specifications shall be stated in the bid. The successful bidder shall submit copies of pertinent drawings. and wiring diagrams for approval.

2.3 OPERATION OF THE SYSTEM

The loss of normal power from the transformer shall automatically cause the generating set to start through Automatic Transfer Switch.

The Diesel generating set shall have an automatic start facility.

The emergency generating set shall be designed so that it will come up to steady full speed from cold condition within 10 seconds of the "start" impulse. It shall then be capable of accepting 100% of its power rating load under power factor variations of 0.8 to unity lagging with maximum transient voltage over or under 5-7 % maximum transient frequency variation of + 5% with steady frequency + 1/2% of nominal (within 5 sec's).

Should the Diesel engine fail to start in 10 seconds following the "start" impulse, it shall come to rest for 10 seconds. Two further attempts shall be automatically performed with intermediate periods of rest. Should the set not start after three attempts, an alarm shall sound and signal "start failure" shall illuminate.

It shall be possible to operate the set manually for testing and normal operation purposes. For this purpose the set shall be provided with a duty selector switch arranged for OFF/TEST/MANUAL/AUTO. It shall be possible to run the engine with or without operation of the Emergency Distribution Board circuit breakers.

The Diesel generator set must still be running a 3-5 minutes after transfer and after removal of all load to ensure that a change-over in the event of a repeated mains failure can rapidly be realized and to obtain a cooling effect to avoid an accumulation of heat.

Noise Attenuation requirements are 75 dB (A) at one meter from air intake and outlet

2.4 EQUIPMENT

A. GENERAL

The engine-generator sets shall be a complete package unit mounted on rigid base suitable for skidding as indicated in the drawings.

The design of the set shall allow the easy replacement of major items subject to wear.

A flexible coupling shall be fitted between the engine and generator to provide the drive and absorb the transmission of shock loads, and shall be completely shielded by a coupling ring and adequate steel guards.

Complete protection from machine vibration is required for the building and all instrumentation and control equipment, including engine-mounted instruments. This may be achieved either by mounting the combined engine/generator unit to a separate sub-frame resiliently mounted on the main frame, or by mounting the entire main frame on anti-vibration mountings, and securing the machine instrument panel by its own resilient mounting. The machine instrument panel by its own resilient mounting. The mountings employed, method of mounting and floor structure and thickness shall be approved by the manufacturer and the Engineer.

2.5 DIESEL ENGINE

The engine shall be of the direct injection four stroke, even number of cylinders dual turbocharged and after cooled and not series turbocharged. It shall operate on diesel fuel oil at 1500 R.P.M. including the capacity to withstand 10% overload for one hour in any period of twelve hours. The net power rating of the engine under worst site conditions shall be such as to deliver the net electric power indicated on the generator taking into consideration generator efficiency.

The lubricating oil system shall be of the full pressure circulating type, complete with full flow lubricating oil filters with replaceable elements and a lubricating oil heat exchanger. Filter system shall be equipped with a spring loaded by-pass valve as an insurance against stoppage of lubricating oil circulation in the event the filters become clogged.

Adequate inspection openings per cylinder to provide quick access and inspection of camshafts and connecting rod.

The fuel system shall be complete and shall be capable of supplying the engine by gravity from a day fuel tank. It shall be equipped with easily replaceable fuel filter elements. The fuel system shall be equipped with a built in, gear type, engine driven fuel transfer pump, capable of lifting fuel against a head of 250 cms. for supplying fuel through the filters to the injection pump at constant pressure.

The exhaust system shall be insulated complete with dry type exhaust manifold with flanges, flexible exhaust expansion connections, exhaust pipes and a residential exhaust silencer which shall be fitted with a drain plug at its lower end to permit evacuation of condensed humidity. The exhaust piping shall be insulated with asbestos tape with a total thickness not below 10 mm.

The size of exhaust pipe should be calculated and determined according to the back pressure limitations as specified by the manufacturer. The back pressure is not reduced the rated power as indicated on the drawings.

The electric starting of the engine shall be possible either manually by means of push button or automatically by means of the automatic control panel. The starting system shall consist of a 24 volts d.c. starter motor, heavy duty 24 volts lead - acid battery and a suitable automatic trickle battery charger. The starting pinion shall automatically disengage when the engine starts.

An isochronous electronic type engine governor with speed control and droop adjustments shall be provided and shall be capable of providing accurate speed control within 1% of the rated speed.

An automatic shut-down protective system with signalling lights shall be provided to shut down the engine in the event of engine overspeed, low lubricating oil pressure, and high cooling water temperature.

Complete shut down system shall be arranged to energize an alarm system located within the plant room and to trip the respective generator circuit-breaker.

The following engine mounted instruments shall be provided :

1. Water temperature gauge calibrated in °C.
2. Lubricating oil temperature gauge calibrated in °C.
3. Lubricating oil pressure gauge.
4. Tachometer.
5. Operating time meter.

6. Oil filter differential.
7. Jacket water temperature.
8. fuel pressure.

2.6 GENERATOR

The generator shall be of drip VDE 0530 proof construction, in accordance with screen protected, revolving field, brush less type with adaptor and flexible coupling for direct connection to the engine at the flywheel end.

Required Generator Characteristics

- i. Type Brush less with salient pole field system incorporating rotating exciter and three-phase rectifier system.

Brush less with salient pole field system incorporating rotating exciter and three-phase rectifier system.
- ii. No. of phases Three with 4 terminals
- iii. Voltage 380 Y/220 - 380 Y/220
- iv. Winding connection - Star with grounded neutral
- v. Net rated output - As indicated on the drawings @ 50 °C ambient temperature.
- vi. Power factor - 0.8 lagging.
- vii. Frequency - 50 Hz.
- viii. Overload - 10% of name plate rating for one hour every 12 hours.
- ix. Insulation - Class "F" stator, class "F" rotor with temperature rise according to class "F" 105 °C over 40 °C ambient temperature Class "F" stator class "F" rotor with temperature rise according to class F 105 °C over 40 °C ambient temperature.

The exciter shall be of the static type with a digital voltage regulator forming an integral part of the alternator.

Overall voltage regulation from no load to full load, including hot to cold, variations and load power factor between 0.8 lagging and unity shall be within + 0.5% of nominal voltage.

Voltage buildup shall be in a positive and rapid manner even when the machine is connected to its load circuit.

The line-to-line voltage waveform shall be at least to the requirements of VDE 0530 (less than 5% deviation. The total harmonics content shall not exceed 3%.

Radio interference suppression shall be at least according to degree "N" of VDE 0875 or equivalent.

Engine-Generator Set Control: The control shall have automatic remote start capability. A panel mounted switch shall stop the engine in the STOP position, start

and run the engine in the RUN position and allow the engine to start and run by closing remote contact, and stop by opening the remote contact when in the REMOTE position.

- a. The control shall include a cycle cranking function. The cranking cycle, nonadjustable, shall consist of an automatic crank period of approximately 10 seconds duration followed by a rest period of approximately 10 seconds duration. Cranking shall cease upon engine starting and running. Two means of cranking termination shall be provided, one as backup to the other. Failure to start after three cranking cycles shall shut down and lockout the engine, and visually indicate an over crank shutdown on the panel.
- b. The control shall shut down and lock out the engine upon : failing to start after the specified time (over crank), over speed, low, lubricating oil pressure, high engine temperature, or operation of a remote manual stop station.
- c. The generator control panel shall have degree of protection IP 54.
- d. The control shall provide a twelve light engine monitor on the control panel; one red light for each of the four shut downs (except the remote manual stop), and one yellow light each for the high engine temperature and low engine oil pressure pre-alarms, and one green run light. The control panel monitor shall include; a flashing red light to indicate the generator set is not in automatic start mode, a yellow light to indicate low coolant temperature, a yellow light to indicate low fuel, and two red lights for auxiliary use (for a total of twelve).
- e. A panel-mounted switch shall reset the engine monitor and test all the lamps. The engine-generator set starting battery(ies) shall power the monitor. Operation of shut down circuits shall be independent of indication and pre-alarm circuits. Individual relay signals shall be provided for each indication for external circuit connections (not to exceed 1/2 amp draw) to a remote annunciator. A common alarm contact for external connection to an audible alarm shall be provided.
- f. Provide a low coolant level shutdown, which shall be indicated as a high engine temperature fault.
- g. Provide the supervised points (control and monitoring) as indicated in fire alarm system section.
- h. Control panel shall be mounted on the generator set with vibration isolators or wall mounted type as indicated on the drawings. The control shall include surge suppression for protection of solid state components. A front control panel illumination lamp with On/Off switch shall be provided. Control panel mounted indicating meters and devices shall include: Engine Oil Pressure Gauge, Coolant Temperature Gauge, DC Voltmeter, and Running Time Meter (hours); Voltage adjusting rheostat, locking screwdriver type, to adjust voltage +/- 5% from rated value; Analog AC Voltmeter scale 0-500 V dual range, 90 degree scale, 2% accuracy; Analog AC Ammeter, dual range, 90 degree scale, 2% accuracy; Analog Frequency meter, 45-65 Hz, 90 degree scale, +/- 0.6 Hz accuracy; Seven position phase selector switch with OFF position to allow meter display of current and voltage in each generator phase.
- i. Provide exerciser clock (2-week type) to automatically start the generator for 30 minutes.

2.7 FUEL SYSTEM

The generator shall be provided with a fuel day tank of capacity sufficient for a 24 hours operation at full load. Fuel shall flow by gravity from the fuel day tank to the engine.

The tanks shall be welded steel, oval with steel support saddles, tapings for accessories, threaded connections. The tanks shall be equipped with tank fill, gages, vent and outlet connections as shown on drawings. The fuel feed line to the day tank shall be of at least 3 cm internal diameter and shall be fitted with a ball valve fitted with a stopcock.

The day tank shall be provided with a breather pipe with replaceable paper type air filter or with breather caps with air filters.

The tanks shall be factory painted with two coat of suitable rust inhibiting metal primer. The tank shall be inclined by at least 3 degrees from the horizontal and a drainage stopcock or plug fitted at the bottom of the end wall of the tank.

The fuel pipe shall be schedule 40 black steel malleable iron fittings.

The main bulk storage fuel tank are provided for a continuous operation of the D/G set. For tank data size and details refer to mechanical division.

2.8 BATTERY TRICKLE CHARGER

A battery trickle charger mounted on the generator control panel shall be supplied with the generator in order to maintain the two battery sets in good condition. It shall be fitted with on-off switch indicator light, input and output fuses and reverse current protection. Upon operation of the plant the charger shall be disconnected from the battery and from the mains. An ammeter to indicate rate of charger and battery voltmeter shall be fitted for each set of batteries.

2.9 ENGINE GENERATOR SUPPORT AND ISOLATION SYSTEM

- A. Equip the engine and generator set with a suitable common steel base for mounting the engine-generator unit on a concrete foundation.
- B. Spring Isolators: Freestanding and laterally stable rated for seismic areas with housings that include vertical resilient limit stops to prevent spring extension when weight is removed; the isolators complete with neoprene acoustical friction pads between the baseplate and supports.
- C. All mounting leveling bolts rigidly bolted to the equipment; spring diameters no less than 0.8 of the compressed height of the spring at rated load; springs to have a minimum additional travel to solid equal to 50% of the rated deflection.
- D. Provide a minimum of six Mason type 'SLR' rated deflection 5 cm, minimum 2500 kg load spring mount and six No. Z1225, minimum 2500 kg "all-directional seismic snubber." Prior to installation, approved manufacturer shall submit installation drawing for approval.

2.10 MISCELLANEOUS

The Contractor shall calculate the reinforced concrete foundation block to support the generating set. Calculation and detailed drawings shall be submitted to the Engineer for approval.

A water pipes shall be installed between the radiator and the engine.

The Contractor shall supply and install all piping cabling and other required accessories and items for a complete emergency generating set.

The Contractor shall supply all the required standard and special tools for routine maintenance and normal over hauls, in suitable cupboard.

The spare parts required for normal operation during 1500 hours operation shall be supplied with the set, and placed in a suitable cupboard. Priced spare part list shall be supplied with the Tender.

Manuals and Technical literature required for operation maintenance and overhaul shall be supplied in English in 3 copies.

2.11 EQUIPMENT DATA/SHOP DRAWINGS

The equipment data to be provided by the Contractor prior to ordering any material covered by this sub-division shall include but not be limited to :

Complete technical data on diesel engine, includes operating characteristics, site rating, fuel and lubricating consumption, manufacturer's catalogue cuts, dimensions and weights, etc.

- Detailed description of all components of the engine: starting system, super charge, governor, injector, cooling radiator, air, fuel and lubricating filters etc.. with manufacutrer's catalogue cuts and operating characteristics.
- Detailed description of all auxiliaries : batteries and charger, fuel day tank, exhaust pipe and silencer.
- Detailed description of engine control, instruments protection, alarms and cut offs, etc.
- Complete technical data on generator and excitation: standards to which it complies, type of insulation, system of cooling system of excitation voltage regulation, etc.. with manufacturer's catalogue cuts.
- List of standard and special tools supplied for routine and major overhauls.
- List of spare parts for 1500 hours operation.
- Operator's manuals, maintenance book and drawings.

The Contractor's shop/construction drawings for installation covered by this sub-division shall include but not be limited to:

Complete drawings of the generating plant in the particular location of the project, with indication of all components, piping exhaust pipes, power and control cabling, etc.

- Construction drawings of the foundation block with indication of holes for anchoring bolts.
- Schematic diagram for power and control wiring.

- Complete lay-out drawings of piping.
- Shop drawings for all supports, frames, louvers plates.
- Plans and elevations of control panels.

2.12 TESTS

Sets shall be available for visual inspection at works by the consultant before loading for despatch to site.

Sets shall be available at works for noise level tests to be made by the consultant before loading for despatch to site.

Performance tests shall be made as specified on the Equipment Data Sheets.

2.13 GENERATOR PROTECTION

The generator shall be protected against all types of excess current that will damage the generator electrical system.

Earth leakage protection shall be provided by means of a 'core balance' residual current device. The restricted earth fault protection level shall be capable of being varied over the range 0.3 amps to 10 amps.

The Contractor shall provide all auxiliary equipment necessary for monitoring the electrical parameters utilized in the protection systems.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine conditions under which diesel engine-driven generator sets are to be installed and notify Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install diesel engine-driven generator set as indicated, in accordance with manufacturer's written instructions, requirements of applicable Standards and in accordance with recognized industry practices to ensure that installation complies with requirements and serves intended function.
- B. Coordinate as necessary to interface installation of engine-generator equipment work with other work.
- C. Lift generator using eyes and other devices provided by the manufacturer.
- D. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors.
- E. Align shafts of engine and generator within tolerances recommended by engine-generator unit manufacturer.

- F. Provide break glass station to shut down engine generator set.
- G. Provide equipment grounding connections for diesel engine-driven generator units as required.
- H. Install diesel fuel piping from diesel engine to day tank.

3.3 FIELD QUALITY CONTROL

- A. Upon completion of installation of diesel engine generator set, test and inspect system to ensure compliance with requirements. When possible, field correct malfunctioning equipment, then retest to demonstrate compliance. Replace equipment which cannot be satisfactorily corrected.
- B. At the construction site, provide the services of a competent, factory trained engineer or technician employed by the manufacturer of the diesel engine generator set to technically supervise and participate during all of the adjustments and tests for the set and major auxiliaries.

Make adjustments and test in the presence of the Owner.

- C. Provide start-up and load test in accordance with NFPA 110 and include the following:

1. A minimum of 3800 liters of fuel oil for testing.
2. Record room temperature and time of beginning of test.
3. Start the units and record the number of seconds it takes each unit to get it started.
4. Record voltage readings on all phases and also running hour meter reading RPM and frequency meter reading. Use a hand tachometer to check RPM against frequency meter reading.
5. Provide load banks for full load rating of generator to test all systems on generator for minimum of 4 hours.

- D. Mechanical Examination

1. Check engine fuel system and water cooling system for possible leaks during the load test. If any fuel or water leaks are observed, stop the unit and tighten or replace the leaking item as required, and restart the load test. It is necessary that each unit run for 2 hours at full load without any leaks or excessive water temperature, low oil pressure, etc., before acceptance.
2. Deliberately speed up the engine by misadjusting the governor and record the speed at which the engine automatically shuts down.
3. Simulate low oil pressure by shorting the contacts of the oil pressure relay, to test for automatic engine shutdown on low oil pressure.
4. Simulate high water temperature by shorting the contacts of the water temperature relay to test for automatic engine shutdown on high water temperature.

5. With engine running under load, during the last half hour of the 2-hour test, measure room and outdoor ambient temperatures. Room temperature not to exceed the motor-generator manufacturer's limit for room temperature with outdoor air temperatures at 35°C design day.

The Contractor to submit this data to the motor-generator manufacturer for computation of equivalent room temperature based upon 35°C day operation. Manufacturer to certify that room temperature data is consistent with manufacturer's recommended operating limits for a 35°C design day.

3.4 INSTRUCTION AND FINAL INSPECTIONS

- A. Laminate or mount under plexiglass a set of operating instructions for the system and install instructions within a frame mounted on the wall near the diesel engine-generator set.
- B. Furnish the services of a competent, factory-trained engineer or technician for five 4-hour periods for instructing personnel in operation and maintenance of the equipment, on the dates requested by the Owner.
- C. Contractor to furnish 5 copies of operating, maintenance and diagnostic instructions and parts list, and illustrated parts books covering the engine-generator and auxiliary equipment which will require operating instructions and periodic maintenance.
- D. Supply one complete set of spare oil, fuel and air filters plus one set of lamps and fuses.

3.5 PERSONNEL TRAINING

- A. Building Operating Personnel Training : Train Owner's building personnel in procedures for starting up, testing and operating generators and auxiliary equipment. Furnish three operator's manual providing installation and operating instructions for each generator.

3.6 DIESEL GENERATOR: SCHEDULE OF SPECIAL TESTING/COMMISSIONING REQUIREMENTS

In addition to the acceptance and type of tests carried out at the manufacturer's works, the following testing/commissioning procedures shall be carried out:

3.6.1 At the manufacturers works

All testing to the satisfaction of the Engineer shall be carried out as follows:

Heat Run

- 50% for ½ hour + 75% for ½ hour..
- 2 hours full load + 1 hour 10% overload.
- i) Recorded ½ hourly readings of speed, oil pressure, oil temperature, water temperature, fuel consumption, battery charge rate and voltage, generator voltage, load current, kilowatt output, frequency and power factor, generator

temperature rise when connected to a resistive/reactive load to produce 0.8 power factor.

- ii) Demonstration of voltage regulations at set point of 385V from full load to no load to full load, including transient variation and response time.
- iii) Demonstration of speed/frequency regulation under conditions of 2 above.
- iv) Cold start, 3 attempts and lockout on set fail.
- v) Cold start, run up and on full load time.
- vi) Demonstration of accuracy of all metering using standard test meters.
- vii) Demonstration of operation and setting of all protective relays and timing devices.
- viii) Demonstration of full sequential operation.
- ix) Demonstration of all alarm and indication.
- x) Temperature rises on generator starter/rotor.
- xi) Installation resistance of generator bed plate wiring and controls.

Records of all tests shall be made in appropriate test folders and initialled by the Contractor and Engineer. These shall be photocopied and 3 No sets provided under the contract.

The Contractor shall provide 14 days notice of tests to the Engineer and shall allow witnessing of tests by the Engineer.

3.6.2 On Site After Installation

The Contractor shall provide all necessary labor, instruments, tools, fuel, lubricating oil and test loads for commissioning tests.

The tests specified below shall be carried out by Contractor in the presence of the Owner's consultant.

The Contractor shall carry out the following:

- i) Check that the base is levelled in all directions, that engine and generator shafts are in proper alignment and that the vibration absorbing devices are properly installed and located.
- ii) Check water and sum oil levels.
- iii) Check the battery and terminal connections.
- iv) Check that the types and grades of fuel and oil are as recommended for the unit.
- v) Fill the main and daily service tank with the correct amount and grade of diesel fuel oil.

- vi) Check that all radiator and engine block water drain points are free from sludge and other blockages.
- vii) Check engine bolts, main drive couplings, valve clearances, fuel pump settings, governor settings, pipeline connections, water hose, exhaust coupling, flexible pipe work, etc.
- viii) Check all connections on the alternator and at the control panel. All lugs for principal connections shall have clean and bright contact surfaces. A suitable abrasive material shall be used where necessary.
- ix) Check access panels and doors for proper opening and closing and for the functioning of any interlocks fitted.
- x) Check all signal and control circuits for correct operation.
- xi) Measure the resistance of stator, rotor, and exciter windings and ensure that this is not less than the Specialist Supplier's figures.
- xii) Start the engine by means of the 'start' push button and allow it to run up to normal speed. Check that during the time the engine starter motor is in operation, the mains battery charger is automatically switched off
- xiii) Check instruments and gauges for normal operation and response and check that the generator voltage is being maintained within the prescribed limits, making due allowance for no-load conditions. Compare the reading of the frequency meter with that of the engine tachometer.
- xiv) Stop engine after 30 minutes. Check water and oil levels.
- xv) Restart set and run at various loads for periods totalling at least 3 hours. Check the voltage and current in each phase in turn and that the voltage and frequency are being maintained with the required limits with large alterations of load. Note the rate of charge on the alternator ammeter with the engine stopped. Check against specialist rates in necessary.
- xvi) Check the operation of the turbo-charger unit and the colour of the exhaust gas at various loads.
- xvii) Check that all the engine safeguards operate satisfactorily.
- xviii) Check the vibration absorbing devices for proper operation and that the performance of all flexible connections, both mechanical and electrical are satisfactory.
- xix) Check the effectiveness of the radio suppression.
- xx) Check the temperature rise in the alternator.
- xxi) Check the operation of all auxiliary fans, motors, pumps, float switches etc, and their associated switching control gear.

When all tests are satisfactory and agreed with the Engineer, the lubricating oil be finally checked, the fuel oil tank replenished and the set left in normal operating order.

When installation of the set and control panel is complete and the installation has been commissioned, they shall be subjected to load tests as follows:

- i) 50% load for ½ hour.
- ii) 75% load for ½ hour.
- iii) 100% load for 2 hours.
- iv) 110% load for 1 hour.

Sound level readings in the following areas to establish compliance with 75 dB at 1 m from generator room.

- a) 1m from generator set room.
- b) 1m from exhaust outlet pipe.

END OF SECTION 23

Section 24
FIRE ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.
- B. General Provisions for Electrical Work, Section 16010, applies to work of this section.
- C. The requirements of this section apply to Fire and Life Safety System specified elsewhere in the specification; coordinate with Division 15 for interface with mechanical systems.

1.2 DESCRIPTION OF WORK

- A. Work includes a complete fire alarm system in all of the buildings and providing all materials, equipment, accessories, services and tests necessary to furnish and install intelligent, Addressable Fire Alarm System of the zoned, non-coded, indicating, fully integrated and field programmable system, closed circuit general alarm (Alarm Sounders and Xenon Flushing Beacon), electrically supervised type. Provide supervised wiring, all operations, and hardware, as described herein and shown on plans.
- B. The system consists of but not be limited to the following :
 - 1. Main Fire Alarm Control Panel (MFACP).
 - 2. System printer at the MFACP.
 - 3. Color Graphic display and keyboard.
 - 4. Fire brigade interconnection (Emergency voice dialer).
 - 5. Telephone line modem.
 - 6. Power Supplies (including spare power supply in each fire alarm control panel).
 - 7. Addressable intelligent manual fire alarm stations.
 - 8. Addressable intelligent area multi-sensor detectors.
 - 9. Addressable intelligent duct smoke detectors.
 - 10. Addressable intelligent area heat detectors.

11. Addressable intelligent area heat detectors fixed temp. at (90 Degree C).
12. Fire Alarm Sounders.
13. Fire Alarm Xenon Flushing Beacon (Strobe Light)
14. Sprinkler water flow switch alarm (Switches wired by this Contractor).
15. Sprinkler valve tamper switch monitoring (Switches wired by this Contractor).
16. Zone addressable modules (for water flow and tamper switches and other non-addressable initiating devices).
17. Addressable Control Modules.
18. Addressable Monitor Modules
19. Central station operation.
20. Interface with all Fire Fighting Control Panels (FM200, CO₂,...etc).
21. Interface with HVAC / Smoke Control System (Supply fans, Exhaust fans, smoke fans and smoke dampers).
22. Interface with public address & voice alarm system to broadcast the Evacuation Message / Alarm Tone in the zones / areas corresponding to fire alarm zones in case of fire alarm condition.
23. Interface with Elevators.
24. Fire Water Pump Monitoring & Alarm (Pump Running, Pump Power Failure & Pump Phase Reversal).
25. Low / High Water Level inside the Fire Water Tank Monitoring.
26. Emergency Diesel Generator Monitoring (Diesel Generator Running & Diesel Generator Fail to Start).
27. Fuel Level inside Fuel Tank Monitoring.
28. Shut down the Fuel Pump Feeding the Diesel Generator in case of Fire at the Generator Room.
29. Fault isolator module (one module should be added in the fire alarm loop, each 15 devices).
30. Software interface with B.M.S. system.
31. Visual monitoring/status of items at the MFACP.
32. Conduits and wires.

33. Approved fused cut-out panels.
 34. Battery and battery/inverter (UPS) back-up operation to maintain the operation of all fire alarm system components in case of power outage.
- C. The fire alarm system is to be installed for addressable initiating and control circuits with hard-wired signalling (alarm bells with strobe light) circuits utilizing conduit, tubing and wire serving all peripheral devices such as manual stations, multi-sensor I detectors, heat detectors and water-flow switches, etc.
- D. Obtain and deliver a final certificate of approval to the Owner from the Fire Department for all fire alarm and detection work under this contract through filing the appropriate documents and including but not limited to the following:
1. Prepare as built riser diagram showing all fire alarm related equipment, wire and conduit sizes and counts and connections to elevator recall, and control equipment, any sub-systems and must include a complete description of system operation. Each drawing to have a standard building department note which reads: "This plan is approved only for work indicated on the application specification sheet. All other matters shown are not to be relied upon, or to be considered as either being approved or in accordance with applicable codes.
- E. It is the responsibility of this Contractor to produce all written requests to the Fire Department for inspections of the fire alarm system and associated equipment.
- Written requests to be produced in a fashion to ensure inspection when equipment is fully operational in accordance with this specification. Contractor to gain final approval in an expedient manner and not to delay the obtainment of a Certificate of Occupancy for this location.
- F. Contractor to be responsible for testing all the fire alarm equipment after completion of work and prior to any inspection with written report given as proof of condition of the system. All system devices and their circuits to be in first class operating condition after completion of work.
- G. Cables
1. All fire alarm system equipment and Cables must be installed in conformance with the VDE/DIN, IEC, BS and National Electrical Code.
 2. All low voltage wiring for the systems must be installed in true Class 'A' form with the 'return' portion of the circuit home run in separate piping. Class 'A' return for more than one circuit may be contained in a common pipe. Class 'A' return pipe(s) must be

labeled as such with lettering, directional arrows or other method to differentiate it from the other circuit pipes.

3. Fire Alarm System Cables to be fire resistant cable according to BS:6387 categories C,W&Z, run in approved conduits throughout.
 4. All raceways are to be concealed in hung ceilings or run in concealed areas to minimize exposure in public corridors and spaces. Where raceways are run in corridors, they must be installed in upper corners at ceiling secured to protect against tampering where possible.
- H. All system components of the Fire Alarm Life Safety system to be U.L. listed by one manufacturer.
- I. Provide a fan schedule indicating all fans that will be shut down under automatic smoke control operations and fans that will have manual override from MFACP including purge fans.
- J. After the completion of the installation of the Fire Alarm System, this Contractor shall perform a complete demonstration test of all systems and devices to the satisfaction of the Owner and their consulting engineer.
- K. Tenant Areas shall be provided by Conventional Detectors / Sounders which shall be connected to the interfaces indicated on the drawings, this contractor to provide all needed DC Connection to the Tenant Interface modules.

1.3 QUALITY ASSURANCE

- A. Manufacturers: firms regularly engaged in manufacture of fire alarm, life safety equipment of types and capacities required, whose products have been in satisfactory use in similar service for not less than 10 years. Provide fire alarm life safety system equipment produced by a manufacturer listed as an Acceptable Manufacturer in this section. Unless submitted components are U.L. listed or Factory Mutual approved in the name of the organization a "manufacturer" will not be considered.
- B. Standards Compliance: comply with requirements of all applicable local codes, NEC, U.L., NFPA, and NEMA Standards pertaining to Fire Alarm, Life Safety systems.
1. The following standards are to be included and recognized as part of the specification for performance and quality of installation and equipment:
 - Local Code
 - NFPA 70 National Electrical Code.
 - NFPA 72 National Fire Alarm Code
 - NFPA 92A Recommended Practice for Smoke Control Systems
 - NFPA 101 Life Safety Code.

- C. In case of conflict among the referenced standards and codes, the more stringent provision will govern.

1.4 SUBMITTALS

- A. Complete Detailed Original Catalogue for the Proposed Manufacturer marked up with all of the proposed Equipment.
- B. List of all types of equipment and components provided including model numbers, mounting accessories and quantities.
- C. Description of operation of the system as described herein, to include all exceptions, variances or substitutions listed at the time of bid.
- D. Manufacturer's printed product data, catalogue cuts and description of any special installation procedures.
- E. Calculations to support size of standby batteries, taken into consideration the Current Consumption feeding the Tenant Detectors / Sounders.
- F. Proposed zone list with description of zones (alarm, monitor) as they would appear on the FACP.
- G. Detailed Voltage Drop Calculation for the DC Lines taken into consideration the Current Consumption feeding the Tenant Detectors / Sounders.
- H. Provide shop drawings as follows:
 - 1. 1:25 scale drawing of Fire Alarm Control Panel and fire command station.
 - 2. 1:50 scale floor plan showing equipment locations, drawings and raceway runs.
 - 3. Fan shut-down, automatic and manual control wiring details. Coordinate with Section 15000.
 - 4. Complete riser diagram showing all equipment and size, type and number of all conductors and conduits.
 - 5. Peripheral device connection details showing all module and device wiring details.
 - 6. Cause & Effect Matrix.
- I. Provide samples of various items, when requested.
- J. Compliance list: submit a detailed point by point compliance statement with this specification. Where the proposed system does not comply or accomplish the stated function or specification

in a manner different from that described and specified, a full description of the deviation shall be provided.

Where a full description is not provided it shall be assumed that the proposed system does not comply with the requirements in the specification.

1.5 OPERATION

A. Activation of any manual pull station, heat detector, duct smoke detector, multi-sensor detector or sprinkler waterflow , to provide the following automatic operations:

1. Sound a pulsing audible signal at the Fire Alarm Control Panel. Pressing the alarm acknowledge key on the Fire Alarm Control Panel shall silence the audible signal during the alarm condition. Subsequent alarm conditions shall again sound the audible signal.
2. Flash the general alarm LED indicator on the Fire Alarm Control Panel. Pressing the alarm acknowledge key on the fire alarm control panel shall continuously light the general alarm LED indicator during the alarm condition. Subsequent alarm conditions shall again flash the general alarm LED indicator.
3. Display a general alarm indication and system status summary (numbers of alarm, supervisory and/or trouble conditions) on the Fire Alarm Control Panel Liquid Crystal Display (LCD). Pressing the alarm acknowledge key shall display, for 30 seconds, the individual device display, to include the "alarm" status and custom label (up to 40 characters and spaces) for the addressable device reporting the alarm condition. At the end of the 30 second period, the general alarm indication and system status summary shall again be displayed.

The individual device display may be recalled at any time by repressing the alarm acknowledge key or until the alarm condition is reset to normal.

4. Enter the custom label for the device reporting the alarm condition with time and date of occurrence into the fire alarm control panel historical alarm log for future recall.
5. As per the positive alarm sequence – detailed in NFPA 72 - Activate the Strobe Light and Sound the alarm signal throughout the building Alarm Zone. (Alarm Signal shall be by the Pre-recorded message via the Public Address & Voice Alarm System in the Mall Area and shall be by the Sounders at the Car Park, Staff Areas and Roof as indicated on the drawings). The alarm signals may be

silenced during the alarm condition by operation of the Fire Alarm Control Panel alarm silence switch. Subsequent alarm conditions shall initiate the voice alarm & strobe light.

6. Automatically start the HVAC / Smoke Control Sequence of operation as detailed in the cause & effect matrix. Give visual status of fan(s) & Dampers at FACP. Manual Pull Station should not start the HVAC / Smoke Control Sequence of operation. Coordinate with Mechanical HVAC / BMS Drawings and Specifications.
7. Recall the Building Elevators to the Entry Level.
8. Send an alarm signal to a Central Station monitoring facility to dispatch the Fire Department.
9. Activate the Color Graphic Station to show in graphics the alarm activation and to include the time and date and custom label for the device reporting the alarm condition.
10. Activate the system printer to printout a hard copy record of the alarm activation to include the time and date and custom label for the device reporting the alarm condition.
11. Activate the auto-dialler module..

1.6 System Supervisory

- A. The following equipment or devices associated with the fire alarm system shall be supervised for normal and off/normal conditions:
 1. Sprinkler valve tamper switches.
 2. Fire pump power failure and phase reversal.
 3. Emergency generator running and failure to start.
 4. Fire Fighting Single Detector Activation.
- B. Activation of any items in B.1 above to automatically:
 1. Sound an audible signal at the Fire Alarm Control Panel. Pressing the supervisory acknowledge key on the Fire Alarm Control Panel shall silence the audible signal during the off/normal condition. Subsequent off/normal conditions shall resound the audible signal.
 2. Flash the general supervisory service LED indicator on the Fire Alarm Control Panel. Pressing the supervisory acknowledge key on the Fire Alarm Control Panel shall continuously light the general supervisory service LED indicator during the off/normal condition. Subsequent

off/normal conditions shall again flash the general supervisory LED indicator.

3. Display a general supervisory indication and system status summary (numbers of alarm, supervisory and/or trouble conditions) on the Fire Alarm Control Panel Liquid Crystal Display (LCD). Pressing the supervisory acknowledge key shall display, for 30 seconds, the individual device display, to include the "off/normal" status and custom label (up to 40 characters and spaces) for the supervisory device reporting the off/normal condition.
4. At the end of the 30 second period, the general supervisory indication and system status summary shall again be displayed. The individual device display may be recalled at any time by repressing the supervisory acknowledge key or until the off/normal condition is restored to normal.
5. Enter the custom label for the zone reporting the off/normal condition with time and date of occurrence into the Fire Alarm Control Panel historical trouble log for future recall.
6. Activate the Color Graphic Station to show the off/normal activation to include the time and date and custom label for the device reporting the off/normal condition.
7. Activate the system printer to printout a hard copy record of the off/normal activation to include the time and date and custom label for the device reporting the off/normal condition.

1.7 SYSTEM TROUBLES

- A. Fire Alarm System to be electrically supervised to automatically detect and report trouble conditions as follows:
 1. The fire alarm system wiring (except control wiring between fans and their control zone addressable module) shall be electrically supervised to automatically detect and report trouble conditions to the Fire Alarm Control Panel.
 2. Any opens or grounds on Monitor Zone Addressable Module alarm initiating, supervisory or status monitoring circuit wiring and any opens, grounds or shorts across addressable data communications, alarm signal or alarm light wiring shall initiate a system trouble condition.
 3. System addressable devices shall be supervised for placement and normal operation. Removal of an addressable device or the failure of its internal electronic circuitry shall initiate a system trouble condition.

4. Operation of the central station agency alarm disconnect switch or any manual control commands that alter the system from its normal programmed standby configuration shall initiate a trouble condition.

5. Fire Fighting Control Panels Trouble

B. Trouble conditions shall automatically:

1. Sound an audible signal at the Fire Alarm Control Panel. Pressing the trouble acknowledge key on the Fire Alarm Control Panel shall silence the audible signal during the trouble condition. Subsequent trouble conditions shall resound the audible signal. The audible trouble signal shall also resound at programmable time intervals to remind the system operator that the trouble condition(s) still exists.
2. Flash the general system trouble LED indicator on the Fire Alarm Control Panel. Pressing the trouble acknowledge key on the Fire Alarm Control Panel shall continuously light the general trouble LED indicator during the trouble condition.
3. The visual indication shall remain on until the trouble condition is restored to normal. Subsequent trouble conditions shall again flash the general trouble LED indicator.
4. Display a general trouble indication and system status summary (numbers of alarm, supervisory and/or trouble conditions) on the Fire Alarm Control Panel Liquid Crystal Display (LCD). Pressing the trouble acknowledge key shall display, for 30 seconds, the individual device or circuit display, to include the "trouble" status and custom label (up to 40 characters and spaces) for the addressable device or circuit reporting the trouble condition. At the end of the 30 second period, the general trouble indication and system status summary shall again be displayed. The individual device/circuit display may be recalled at any time by repressing the trouble acknowledge key or until the trouble condition is restored to normal.
5. Enter the custom label for the device or circuit reporting the trouble condition with time and date of occurrence into the fire alarm control panel historical trouble log for future recall.
6. Activate the Color Graphic Display to show the trouble condition activation to include the time and date and custom label for the device or circuit reporting the trouble condition.
7. Activate the system printer to printout a hard copy record of the trouble condition activation to include the time and date and custom label for the device or circuit reporting the trouble condition.

1.8 CAUSE & EFFECT MATRIX

- A. The contractor shall provide a detailed cause and effect matrix as a shop drawing which shall reflect all details about the fire alarm conditions, supervision conditions and trouble conditions for all fire alarm system components and all related systems and equipment (HVAC, Public Address, Elevators,...etc).
- B. Cause & Effect Matrix shall include – but not be limited to - the following:
 - 1. Composite Drawings indicating the Fire Alarm, Voice Alarm System and the HVAC & Smoke Control System.
 - 2. Detailed table for the HVAC & Smoke Control Equipment complete with the relevant Control / Monitor Modules.
 - 3. Table for all other Control / Monitor Modules for Public Address, Elevators, Generator Sets, Fire Pumps, Fire Fighting Panels...etc.

1.9 SYSTEM WALK TEST

- A. The Fire Alarm Control Panel shall permit one person system walk test. The walk test mode shall be passcode protected, requiring the entry of a minimum five digit passcode before the walk test mode is enabled.
- B. Fire alarm system addressable devices may be divided into as many as eight groups for testing purposes. Putting one group into the walk test mode shall not impair the normal operation of the remaining seven groups.
- C. When a group of addressable devices is put into walk test mode, the alarm verification function, if provided, shall be disabled in order to expedite testing.
- D. The walk test mode may be enabled for a programmable amount of time up to 8 hours. If no devices in the system/an enabled group have been activated during the programmed time, the Fire Alarm Control Panel shall automatically revert to normal system operation.
- E. When placed in the walk test mode by authorized personnel, activation of any alarm initiating device shall:
 - 1. Sound a pulsing two second signal on all audible alarm signalling devices.
 - 2. Log the alarm condition in the Fire Alarm Control Panel historical trouble log for future review/recall.

3. The Fire Alarm Control Panel shall automatically reset itself after each alarm test.
- F. When placed in the walk test mode by authorized personnel, momentary disconnection of addressable data communication, alarm initiating, supervisory or alarm signalling circuit wiring shall:
1. Sound a continuous four second signal on all audible alarm signalling devices.
 2. Log the trouble condition in the Fire Alarm Control Panel historical trouble log for future review/recall.
 3. The Fire Alarm Control Panel shall automatically reset itself after each circuit's wiring is reconnected.

1.10 QUALIFICATIONS OF MANUFACTURER

- A. Manufacturer and/or supplier of system specified shall have following qualifications and submit documentary evidence of same:
1. Existence at time of bidding of local factory authorized office near project site, with staff of factory trained engineers and technicians who are qualified to provide instruction, routine and emergency maintenance and repairs on portions of systems. Proof to include evidence of at least three similar installations currently in satisfactory service. Installations by another distributor of proposed manufacturer will not be accepted as proof.
 2. Having 10 years or more of experience in successful application, installation and operation of computerized systems, and sub-systems, as herein specified and noted.
 3. Provide written guarantee that local office will be maintained with qualified staff of engineers and technicians for an agreed upon period.

1.11 TRAINING OF CONSOLE OPERATORS

- A. Manufacturer to train not less than 5 operators of console, with personnel on job instruction provided by competent engineer representing Manufacturer.
- B. Manufacturer to provide each operator with complete, printed operating instructions and brief sub-system description in manual or handbook form.
- C. Manufacturer to provide two distinct training sessions, with minimum training time of one day each. Sessions scheduled to suit requirements, may be scheduled at any time from award of contract to end of guarantee period at owner's request.

- D. Manufacturer to train operators in preventive maintenance of console printers and other equipment, inclusive of replacing paper, tapes and bulbs.
- E. Manufacturer to furnish letter stating that operators have completed training operation of system.

1.12 COORDINATION

- A. Contractor to coordinate with Mechanical Contractor and Section 15000 for installation of duct mounted smoke detectors and motor controls.
- B. Contractor to coordinate with Sprinkler Contractor and Section 15000 for interface with sprinkler devices.
- C. Contractor to coordinate with Architect for final locations of devices and appearance.

1.13 ZONING OF DEVICES (FOR LED ANNUNCIATION AT (MFACP)

- A. Manual Alarm Stations: Provide one alarm zone per floor.
- B. multi-sensor Detectors: One detector zone per floor plus individual zone for all electric rooms/closets per floor and mechanical rooms per floor.
- C. Sprinkler Water Flow Switches: Individually zoned per switch for alarm.
- D. Sprinkler Valve Tamper Switches: Provide one monitor zone for each switch or a maximum of two switches per zone if serving the same sprinkler branch line.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

Refer To The Attached Manufacturer's List.

2.2 SYSTEM CABLES

All cables should have color code conductors and to be as per manufacturer recommendation, Cables shall be fire resistant according to BS:6387 Categories C, W & Z and shall have Low Smoke Zero Halogen Jacket.

2.3 MATERIAL

Wire and Conduit: Provide in accordance with system requirements as stated herein and by the manufacturer in accordance with all applicable

codes and authorities having jurisdiction and installed in conduit throughout.

2.4 EQUIPMENT

A. Basic System Equipment, Addressing and Operating Capabilities

1. The addressable intelligent fire alarm system shall provide an individual multiplex data address for each addressable manual fire alarm station, addressable multi-sensor detector, addressable heat detector, Monitor Zone Addressable Module and Control Zone Addressable Module.
2. The Fire Alarm Control Panel shall provide Standard 72, addressable intelligent data communications circuits to provide connection of and communication with the addressable devices, as required by these specifications and/or as shown on the drawings.
In order to permit future additions, no more than 80% of the addresses available on any single addressable data communications circuit shall be utilized.
3. Addressable, intelligent data communications between the Fire Alarm Control Panel Addressable Interface Circuit Modules and addressable intelligent devices shall be digital transmissions which shall consist of multiple 11 bit messages with start, data, parity and stop bits.

Address, parity, overrun, framing and check sum tests must be passed for any message to be considered valid. Addressable data communications circuits between the Fire Alarm Control Panel and addressable devices shall operate at 4800 baud. Each NFPA 72, Style 6 (Class A, four-wire) addressable data communications circuit shall be capable of communicating with an addressable device up to 375 wiring meters distant and with a total up to 1,500 meters of wiring in all branches.

4. Monitor Zone Addressable Modules (intelligent type) shall be provided to connect to and provide individually addressed alarm initiating, supervisory or status monitoring circuits for non-addressable devices such as sprinkler waterflow alarm switches, remote building(s) alarm and trouble, sprinkler valve tamper switches, fans and/or dampers. Each Monitor Zone Addressable Module shall provide one NFPA 72, Style D (Class A, four wire) supervised circuit. Assignment of individual MZAM circuits for alarm, supervisory or status monitor operation shall be accomplished during the programming of the Master Controller Module Central Processing Unit (CPU) software.
5. Control Zone Addressable Modules (intelligent type) shall be provided to connect to and provide Fire Alarm System Control of remote equipment such as air handling systems and smoke fans, ... etc..

Each Control Zone Addressable Module shall provide one individually addressable control relay with Double-Pole, Double-Throw (DPDT) contacts fused. Assignment of individual CZAM relays for control operation shall be accomplished during the programming of the Master Controller Module Central Processing Unit (CPU) software.

Each of the following types of equipment shall be provided with a CZAM control relay typically as follows:

- a. Fans: Provide two control modules for each fan (including the Air Handling Unit Fans) to provide full fire alarm control / monitoring and as required by the Mechanical Specifications and Local Codes and authorities.
 - b. Smoke dampers: provide one control module for each HVAC fire smoke damper. The quantities of these control modules shall be taken from the HVAC design documents.
6. Each of the following types of remote equipment associated with the fire alarm system shall be furnished with a manual control switch at the Fire Alarm Control Panel, as required by the functional requirements of these specifications, but shall be typically as follows:
- a. Provide a switch with LED status for disconnection of Central Station signaling.
 - b. Provide a switch (ON / OFF / Auto) with LED status for each fan (including the Air Handling Unit Fans).
 - c. Provide a switch (OPEN / CLOSE) with LED status for each Smoke Damper.

Contractor to follow the NFPA 92A Recommendations for the Fire Fighter's Smoke Control Station FSCS.

- B. Fire Alarm Control Panel(s): The Fire Alarm System Control Panel(s) shall incorporate all control, alarm, relay and necessary modules and components in surface mounted cabinets. The operating controls and zone/supervisory indicators shall be located behind locked, steel door/Plexiglas window assemblies, with keys made available only to Fire Department and other authorized operating personnel. All control modules shall be labeled, all zone locations shall be identified, and the panel shall be provided with a set of permanently mounted operating instructions.

The panel, door and frame assembly shall be steel, with red finish. The panel shall contain system power supplies, data bus conductors, battery charger and all necessary function modules

and components, including but not necessarily limited to the following:

1. Master Controller Module: A panel shall be provided to act as a central processing, indicating and control location for the fire alarm system and shall include:
 - a. Solid state, microprocessor based, Central Processing Unit (CPU) to process all system data and generate all system automatic alarm functions. Any addressable device or conventional hard-wired alarm initiating, supervisory or status monitoring circuit may be software programmed to activate any system control relay or signaling circuit. All control-by-event programming, custom LCD display labels and alarm codes shall be stored in non-volatile solid state memory, which shall be on-site programmable.
 - b. Four levels of access to system control and software functions. Level 1 shall be the lowest level of access and shall not require a pass-code. Levels 2, 3 and 4 shall require a pass-code of up to ten digits, with Level 4 being the highest (most restricted) level of access. System software shall permit up to 20 individual pass-codes to be programmed into the system.
 - c. Solid state memory for alarm and trouble historical logs. Each log, alarm or trouble, shall be capable of storing up to 300 events with the time and date of occurrence.
 - d. A module placement supervisory circuit through the module data conductors.
 - e. 80 character, alphanumeric, backlit, Liquid Crystal Display (LCD).
 - f. System alarm LED indicator with alarm condition acknowledge button.
 - g. System supervisory condition LED indicator with supervisory condition acknowledge button.
 - h. System trouble condition LED indicator with trouble condition acknowledge button.
 - i. System power on LED indicator.
 - j. System alarm silence button.
 - k. System reset button.
 - l. Central station alarm disconnect switch with "activated" LED indicator.

- m. Four programmable control switches with "activated" LED indicators.
 - n. An alarm/trouble audible signal.
 - o. Display action and data entry/control keypads.
 - p. Two NFPA 72, Style Z (Class A, four-wire) alarm signaling circuits.
 - q. Two alarm operated Single-Pole, Double-Throw (SPDT) relays.
 - r. One trouble operated Single-Pole, Double-Throw (SPDT).
2. System Meter Module: The system meter module shall provide visual indication of system voltage and supervisory current. The meter module shall contain a voltmeter with a range of from 0 to 50 VDC for indicating system voltage. The module shall be readily disconnected for ease of servicing and placement supervised via its connection to the Master Controller Module.
 3. Addressable Interface Module: The addressable intelligent interface module(s) shall provide one addressable data communications circuit to enable the Fire Alarm Control Panel to communicate with the addressable devices. Each addressable data communications circuit shall provide NFPA Standard 72, Style 6 (Class A, four-wire) supervised operation. When wired for NFPA Standard 72, Style 6 (Class A, four-wire) operation, a single open or ground fault shall not impair a circuit's operation. Addressable data communications circuit wiring shall be supervised for opens in the circuit, shorts across the pair and ground faults. An addressable data communications circuit fault shall initiate a system trouble display and audible trouble signal at the Fire Alarm Control Panel.

Faults on one addressable data communication circuit shall not impede operation of other circuits. The module shall be readily disconnected for ease of servicing and shall be placement supervised by the Master Controller Module.

Provide available spare space in the FACP for a minimum of two future addressable interface modules.

4. Indicating Appliance Signal Circuit Modules: The indicating appliance signal circuit module(s) shall provide six independently controllable alarm signal circuits. Each alarm signal/speaker circuit shall be configured for NFPA 72, Style Z (Class A, four-wire) supervised operation monitoring for opens, shorts or ground faults. When wired in the Class A,

four-wire configuration, a single open or ground fault shall not prevent the activation of the alarm signal devices.

When a circuit fault is detected, the module shall light the general trouble LED on the Master Controller Module and initiate a system general trouble condition.

Each signal circuit shall be protected by an individual fuse on the module. The module shall be readily disconnected for ease of servicing and placement supervised by the Master Controller Module.

5. Auxiliary Control Relay Modules: The auxiliary control relay module(s) shall provide relays and their bases, complete with terminals for Contractor wiring, for control of external equipment functions. Each module shall provide eight independently, controllable, Single-Pole, Double-Throw (SPDT) relays. Each relay shall also be provided with a supervised, status monitoring circuit to monitor the status of the controlled device (status contacts provided by others).

The module shall be readily disconnected for ease of servicing and shall be placement supervised by the Master Controller Module.

6. Communication Module: The module shall provide two communications ports with ASCII output (adjustable baud rate) for operation of system printers and/or cathode ray tubes (CRT'S).
7. Emergency Voice Dialer: shall be provided with following facilities:
 - 2 channels input
 - Total recording time is 60 sec., splitted between No. 6 messages.
 - 8 telephone numbers
 - Dialing mode (DTMF/ PULSE)
 - Call list, priority order, communication delay, call progress function & message report facilities should be included.
8. Telephone Line modem: It converts data in the RS232C format to or from FSK modulation to permit data communications over leased/dedicated telephone lines to remote system devices such as CRT displays and printers. It shall be capable of providing either half-duplex (two-wire) or full duplex (four-wire) operation.

The modem shall provide a power-on LED indicator and six diagnostic LED indicators for: receive data, transmit data, carrier on, clear to send, request to send, and data set ready.

9. Battery Pack: The fire alarm system shall be provided with battery backup capability. The batteries shall provide 24-hours of normal standby operation and 30 minutes of normal alarm operation at the end of the 24-hour standby period. The batteries shall be placement and high/low voltage supervised by the Master Controller Module.

All battery charging and recharging operations shall be automatic.

Standby power for the system shall be produced by maintenance free, sealed, lead acid or nickel cadmium batteries. The system batteries shall be supervised so that a low battery condition or disconnection of the batteries shall be audibly and visually annunciated at the control panel. Battery chargers shall have the following operating characteristics :

- a. Ability to charge batteries to 90% of their capacity within twelve (12) hours.
- b. Compatible with either lead acid or Ni-cad batteries.
- c. All circuits requiring system operating power shall be individually fused.

10. Each fire alarm control panel shall be provided complete with spare power supply, and free space for two cards for future extension.

- C. Peripheral Devices: The following material to be supplied and installed as indicated on the drawings:

- a. System Color Graphic Display with touch screen Display and Keyboard :

The display shall have coloured, non-glare, 20 inch diagonally measured screen.

The detachable keyboard shall be of the enhanced, 101 key type and shall permit data communication with the system Central Processing Unit (CPU) to permit the operator to acknowledge system alarms and request status reports. The following feature shall be available:

- Graphical Annunciation and Control.
- Up to 25,800 Custom Graphic Screens, Field Generated/Edited Via Auto CAD DXF File Format Drawing Tools.
- Custom Alarm and Trouble Messages Guide Operator dispatch response
- Seven Access Levels for 256 Users.
- Includes Network Interface for Wired or Fiber Optic Communications.

- 20" High Resolution Monitor.
- Desk Top Enclosures.
- Touch-screen and Mouse Operation.
- Extensive Historical Logging: Up to 500,000 Events.
- Compatible with Spread Sheet and Data Base Programs for Report Customization.
- Operator Notations can be added.
- Graphical Diagrams Tools Identify Exact Status of Network Nodes and Wiring.
- Dial-Up Service Modem for Remote Access.
- RS232 Ports for Connection to Printers, Paging Systems, or Third Party Systems.

b. System Printer: The printer shall be provided with the following operational capabilities:

- a. A permanent hard-copy record of all pertinent details of system activity. Included on this record shall be all unscheduled status change events, all operator acknowledgments of these events and all operator control commands into the system and the time and date of all occurrences.
- b. The system printer shall record all alarm, supervisory and trouble conditions by address number and custom label. The custom label, of up to 40 characters and spaces, and time and date of alarm, supervisory or trouble condition activation shall be printed out in a language text so that the source of the condition is clearly understood without referring to a code directory. Printout by address or code number only shall not be as considered functionally equivalent.
- c. The custom label (location message), of up to 40 characters and spaces, for a specific device or circuit shall correspond to that displayed on the Fire Alarm Control Panel Liquid Crystal Display.

- c. Addressable Manual Fire Alarm Stations: Double Action (lift cover and pull alarm lever), non-coded type manual station, of cast metal construction, with normally open, Single-Pole, Single-Throw general alarm contacts. The manual station shall include an addressable module which shall consist of printed circuit board with discrete circuitry for monitoring the station alarm contacts. When operated, the alarm lever shall remain in its "down" position to indicate its operation, with alarm contacts closed until the station is reset. The station shall be reset by opening the front, resetting the lever and closing the station front.

The station shall be tested by opening the station front and then returning same to normal. It shall be necessary to open the

station to replace the break rod. A spare break rod shall be furnished with each station.

- d. Addressable intelligent multi-sensor detector: shall integrate two sensing technologies (photoelectric smoke and heat detection). The detector shall gather analog information from each of its fire sensing elements and converts it into digital signals which shall be measured and analyzed separately by the detectors microprocessor with respect to time. The detector should be UL listed and provided with surface mount, addressable base assembly with an alarm LED indicator and screw terminals for all connections. The addressable base shall respond to polling signals from the fire alarm control panel and shall report alarm or trouble status changes. Base assemblies shall provide detector twist / lock capability.
- e. Addressable intelligent Heat Detectors: Shall be combination rate-of-rise alarm function and fixed temperature element heat detector. Activation of the rate-of-rise or fixed temperature alarm functions shall be self-restorable when the ambient temperature stabilizes. Each detector shall utilize solid state components and shall be listed for U.L. Standard 521. Detectors shall be provided with surface mount, addressable base assembly with an alarm LED indicator and screw terminals for all connections. The addressable base shall respond to polling signals from the Fire Alarm Control Panel and shall report alarm or trouble status changes. Base assemblies shall provide detector twist/lock capability.
- f. Addressable intelligent area heat detector (90°C): in generator rooms, a fixed temperature (90° c) heat detector shall be used. The detector shall be self restorable type and complete with surface-mount addressable base assembly.
- g. Monitor Zone Addressable Modules: Shall be individually addressable alarm initiating/supervisory circuit board(s) and shall consist of printed circuit board with discrete circuitry for monitoring normally open, dry contacts using NFPA 72, Style D (Class A, four-wire) circuit supervision. The monitor shall respond to polling signals from the Fire Alarm Control Panel and shall report alarm initiating/supervisory circuit status changes to it. The monitor shall include a field programming capability for the assignment of its individual address number and clamp-type terminals for making wiring connections.
The monitor module shall draw its power from the Fire Alarm Control Panel via a separate power circuit. The monitor shall be furnished for flush mounting or surface mounting, where shown on the drawings.
- h. Control Zone Addressable Modules: Shall be individually addressable control relay and shall consist of printed circuit board with discrete circuitry for controlling one individually addressable

control relay with Double-Pole, Double-Throw contacts. The control shall respond to control signals from the Fire Alarm Control Panel. Control Module shall have a feedback contacts for monitoring of the controlled devices.

The control shall include a field programming capability for the assignment of its individual address number and clamp-type terminals for making wiring connections. The control shall draw its power from the Fire Alarm Control Panel via a separate power circuit.

- i. Duct Smoke Detectors: UL 268A listed, addressable, intelligent photoelectric type, incorporating sampling tubes and housing designed for this application. Duct mounted smoke detectors hidden from view to be supplied with remote indicating pilot lights for wall/ceiling mounting near the location of the hidden detector. Duct Smoke detector to be of the same manufacturer as the control equipment and incorporate a built-in test station and remote indicator.
- j. Fire Alarm Sounder: Provide alarm sounders in the areas as indicated on the drawings, the Sounders shall have a sound pressure level of 92dB @ 1m, Sounder Tone shall be selectable.
- k. Xenon Flushing Beacon (Strobe Light): Provide Strobe Light with 75 cd according to UL 1971, It shall be either Ceiling or Wall Mounted type.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine areas and conditions under which fire alarm system is to be installed. Notify Owner in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install fire alarm devices, wiring and main equipment as indicated, in accordance with manufacturer's written instructions, requirements of applicable Standards, and in accordance with recognized industry practices to ensure that installation complies with requirements and serves intended function.
- B. Coordinate as necessary to interface installation of fire alarm system with other work.
- C. Protect all equipment from dirt, moisture and construction debris, subsequent and during installation until project is accepted by Owner.

- D. Fire stop penetrations of floor slabs or fire walls in accordance with all local codes.
- E. Contractor to furnish all conduit, wiring, outlet boxes, junction boxes, cabinets and similar devices necessary for a complete installation. All wiring types as recommended by the manufacturer installed in conduit throughout or as approved by the local Fire Department. Junction boxes to be painted fire department red for identification.
- F. End of Line Devices (Resistors/Diodes/Capacitors): Shall be furnished as required for mounting as directed by the manufacturer to electrically supervise all wiring.
- G. All wiring shall be color coded throughout, to local or National Electrical Code Standards. All wiring shall be of the type recommended by the manufacturer, type Flame retardant, and shall be installed in dedicated, rigid, threaded, steel, galvanized conduit throughout. Provide flex conduits at waterflow, tamper and smoke vent connections.
- H. All wires shall test free from earth (grounds) or crosses between conductors.
- I. Circuit wiring from the Fire Alarm Control Panel to the system peripheral equipment shall be as per the manufacturer recommendations, contractor to provide detailed Voltage Drop Calculation for all of the DC Lines.
- J. Fire alarm system terminal and junction locations shall be identified in accordance with NFPA Standard 70, Section 760-3. Terminal and junction boxes shall be painted red and stenciled in white letters "FIRE ALARM," preventing unintentional interference with the fire alarm system wiring during testing, servicing and additional modifications to the system.
- K. The system shall be arranged to receive power from three-wire, 400/230 volt, 50 Hertz alternating current supply through fused cut-out, as shown on drawings. All low voltage operation shall be provided from the Fire Alarm Control Panel(s).
- L. All final connections between system equipment and the wiring shall be made under the supervision of a trained manufacturer's technical representative.
- M. Wiring within component enclosures and terminal cabinets: All wiring shall be installed in a neat and workmanlike manner and shall be trained parallel with or at right angles to the sides and back if any enclosure or cabinet.

All circuit conductors broken, spliced, or connected in any enclosure, cabinet, mounting or junction box shall be connected to terminal blocks with each terminal spade lugs or with approved pressure type terminal blocks. A terminal cabinet shall be installed where any circuit tap is made and must be painted fire department red. All wiring within the

enclosure shall be readily accessible without removing any component parts.

- N. All conductors shall be installed in rigid heavy metal conduit or electrical metallic tubing run surface or concealed and as required by applicable codes. Each conductor used for the same specific function shall be distinctively color coded and must be clearly identified at both terminal points. Wiring for the fire systems shall be installed as herein described and separate from any other wiring systems.
- O. Secure the base of each ceiling mounted products of detectors to boxes, either flush or surface mounted as required. Secure detector heads to the bases.
- P. Provide all required evacuation speakers. Speakers shall be flush ceiling mounted cone type and surface mounted horn type as indicated, each complete with a proper back box. Ensure that exterior speakers are weatherproof and mounted with a weather sealed gland nut connection at the proper dispersion angle. Speaker grille finishes to be confirmed with Project Manager.
- Q. Flush mounted ceiling mounted speaker back boxes must be supported from the structure and not the suspended ceiling grid or tiles. Speakers should be connected to the specified taps .
- R. Provide engraved lamaroid identification nameplates for each equipment or wiring housing and secure to the front of the housing. Exact wording designations and sizes to be reviewed and confirmed with the Project Manager prior to manufacturer
- S. Confirm the exact location of all components prior to roughing-in.

3.3 CLEAN UP

- A. Upon completion of the installation, all debris created by the installation shall be removed from the premises or disposed of as directed by the Owner.

3.4 FIELD QUALITY CONTROL

- A. Upon completion of installation of Fire and Life Safety System and after system has been energized, test equipment to demonstrate compliance with requirements. Field correct or replace defective equipment, and retest.
- B. A factory trained technician to supervise the final connections, tests and adjustments of all equipment upon completion. Each device be tested by the manufacturer's representative, in the presence of the owner's representative; a test report completed in

triplicate, and signed by the owner's representative to indicate that he witnessed the testing of the system.

A copy of the test report shall be posted adjacent to the Fire Alarm Control equipment and enclosed in a glass directory stainless steel frame.

- C. Upon completion and prior to all acceptance, perform complete system tests as follows:
 - 1. Actuate all manual and automatic alarm and monitor initiating devices one at a time and verify proper operation.
 - 2. Verify:
 - a. Operation of all signaling and indication systems as specified including proper zone identification and labeling at the Fire Alarm Control Panel.
 - b. Fan shut-down.
 - c. Transmission of alarm to security office.
 - d. Manual control of items as specified.
 - e. Class and type of wiring.
 - f. Automatic operations of specified items.
 - 3. Power:
 - a. Verify operation of standby power sources as follows:
 - 1) Remove primary power and check for battery operation as specified.
 - 2) Remove primary power and check for automatic switch-over to secondary source.
 - 4. Check for proper sequence and priorities.
- D. Submit 5 copies of test data and results, signed by test personnel.
- E. Correct or adjust items not found acceptable by authorized representative.
- F. Repeat tests to indicate corrected items.

3.5 GUARANTEE

- A. All components, parts and assemblies supplied by the manufacturer to be guaranteed against defects in materials and workmanship for a period of 12 months from Owner and fire department acceptance.

- B. Equipment manufacturer to have a local branch office staffed with trained, full-time employees who are capable of performing testing, inspection, repair and maintenance services for the life of the System.
- C. Contractor to guarantee all wiring to be free from inherent mechanical and electrical defects for one year.

The manufacturer to furnish a one-year maintenance contract, free of charge to the owner, effective from the date of installation for maintenance and inspections of the manufacturer's equipment; with a minimum of two inspections during the contract year. A local manufacturer service department which stocks standard parts to be available to the owner. If required, maintenance is to be performed during normal working hours, at no cost to the owner, for a period of twelve months from the completion date of the installation, unless damage is caused by misuse, abuse or accident.

3.6 SERVICE AND MAINTENANCE

- A. The equipment manufacturer shall make available a fully equipped service organization, capable of guaranteeing an on-site service response time within 8 hours to a service request call. Site service shall be available 24 hours per day and seven days per week.
- B. As part of this Contract, the Contractor shall receive from the equipment manufacturer and turn over to the Owner the following system spare parts:
 - 1. 50% spare of each type of fuse.
 - 2. 30% spare of each type of lamp (excluding LED type).
 - 3. 10% spare of each type of alarm initiating device.
 - 4. Other devices as described herein.
- C. The equipment manufacturer shall make available, to the Owner, a price quotation for a one year maintenance and testing agreement, to take effect on the date of final acceptance.

3.7 INTERCONNECTION WITH OTHER SYSTEMS

The system supplier is responsible to provide all required switches, auxiliary contacts, relays, wiring, terminal blocks transducers and software interface to provide signaling and metering information for the central control system and to accept START/STOP, open/close, set point from it.

Relevant signals are listed under controls, BMS and motor control panels drawings and data schedules.

The interface between the fire alarm system and the BMS system shall be via software interface. The system supplier is responsible to provide all software / hardware required to achieve the interface and operation as indicated in this chapter and as indicated on drawings.

END OF SECTION 24

SECTION 25

IP CLOSED CIRCUIT TELEVISION SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions and Division-1 (General requirements) will apply to the work of this section.
- B. General Provisions for Electrical Work, Section 16010, apply to work of this section.
- C. Raceways, Boxes And Fittings, Section 16110, applies to work of this section.
- D. Cable Trunking, Section 16116, applies to work of this section.
- E. Structured Cabling System. Section 16750, applies to work of this section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services, hardware, software, tests and operation and maintenance documentation necessary to complete and make ready for operation, a complete IP based Closed Circuit Television system for the building in accordance with Drawings and Specifications.
- B. The CCTV Systems shall be an IP based system utilizing Network cameras directly connected to Local Area Network (LAN). The IP CCTV System shall be capable of monitoring, controlling and Image storing for cameras located at different areas. Installation shall comply with local code requirements as applicable.
- C. Contractor shall provide full support to the Network Active Equipment Contractor for proper selection of the Network Active Equipment to ensure proper installation & operation of the IP-CCTV Systems.

1.3 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in the manufacturer of IP-CCTV Systems of types, data required, whose products have been in satisfactory use in similar service for not less than five years.
- B. Standard Compliance: provide IP CCTV system and components which Comply with requirements of applicable codes & standards as listed below:
 - 1. National Electrical Safety Code, current edition
 - 2. National Fire Protection Association National Fire Codes, current edition

3. EIA/TIA–568 Commercial Building Telecommunications Wiring Standard
 4. EIA/TIA–569 Commercial Building Standard for Telecommunications Pathways and Spaces
 5. EIA/TIA–606 Administrative Standards for the Telecommunications Infrastructure of Commercial Buildings
 6. IEEE, RS 170 variable standard
 7. NTSC/PAL
 8. IEEE, 802.3 digital data network standard
 9. EIT/TIA–568A premises cabling standard
 10. Compliant with ISO/IEC 14496 standard (also known as MPEG-4)
 11. Compliant with ISO/IEC 14496-10 standard (also known as MGEP-4 Part 10 or H.264)
 12. Compliant with International Telecommunication Union (ITU) Recommendation G.711, “Pulse Code Modulation (PCM) of Voice Frequencies”
- C. When more than one code / regulation are applicable, the most stringent shall apply.
- D. Service: Manufacturer / Supplier must have a warehouse in Qatar at which spare parts are stocked and where a field service engineer who is a permanent, full-time employee of the Manufacturer / supplier, factory trained and qualified individual whose primary duty is field service resides.

1.4 SUBMITTALS

- A. Product Data: Submit Complete, Detailed, and Original Catalogue for the manufacturer and marked up for all of the proposed equipment.
- B. Detailed Bill of material indicating the model number and quantity for all of the proposed equipment.
- C. Complete Detailed Camera Coverage Cone of View Drawings, based on which the supplier / manufacturer to select the proper Camera / Lens for each location ensuring full coverage to all of the Public Areas, Corridors & Car Parking.
- D. Riser Diagram: Submit detailed riser diagram to indicate the connection between all of the system components and the interface with all other system.
- E. Bandwidth Calculation for the Network Active Equipment.
- F. Detailed Storage Capacity Calculation.
- G. Shop Drawings: Submit dimensional layout on architectural background drawings indicating all of the proposed equipment, part numbers, cables, raceways, Etc.

- H. Compliance list: submit a detailed point by point compliance statement with this specification. Where the proposed system does not comply or accomplish the stated function or specification in a manner different from that described and specified, a full description of the deviation shall be provided.

1.5 EQUIPMENT WARRANTY

Guarantee equipment furnished under these specifications against defective parts and workmanship under terms of the manufacturer's and dealer's standard warranties for a period of not less than one year from date of initial start-up and Owner acceptance of the system and include labor and travel time for necessary repairs at the job site.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

Refer To The "List of Recommended Manufacturers".

2.2 GENERAL

- A. System administration shall be available from any workstation in the system. The system specifically must have the capability to support not less than 12 Monitoring / Administration workstations connected on the network at the same time. The IP CCTV System shall allow all connected workstations to function in a true multi-user, multi-tasking environment.
- B. The Operating System shall be based on a Microsoft operating system and / or Linux.
- C. The system shall be capable of modular expansion without software upgrades or wiring revisions.
- D. Final location and fixing methods of all the cameras giving optimum coverage of the areas to be surveyed in accordance with the Cameras Coverage Cone of View drawings will be agreed with the Owner's Authorized Representative. The Contractor will be responsible for suitable bracket to fix cameras in their final locations. The Contractor will paint all camera housings and bracket to a colour finish subject to approval by the Owner's Authorized Representative.
- E. The system will provide maximum operational simplicity to enable quick and effective use in an emergency. Selected live camera images will appear on the screen in no less than 1 second from key press. There will be no discernable latency between operation of the control joystick and the response of the camera function.
- F. The contractor will provide and install all power supplies necessary for correct operation of the CCTV system. Power over Ethernet shall be provide where applicable by the proposed system manufacturer, The Contractor will liaise with the Client's M&E team to ensure that the power source provided for the entire CCTV system is the same, single phase at 220V/50Hz,

- G. Backup power shall be provided for the IPCCTV Equipment distributed in the IT Rooms as detailed in the Structured Cabling System Specifications.
- H. All control and monitoring components will be designed for mounting into a 19 inch standard rack and will consist of modular, unit type assemblies to facilitate removal, maintenance and system expansion.
- I. All equipment and materials used will be standard components, regularly manufactured and regularly utilized in the manufacturer's system. All systems and components will have been thoroughly tested and proven in actual use.
- J. The External CCTV Cameras shall be supplied with the necessary poles and mounting for proper installation. The Poles shall have suitable specifications taken into consideration the pole stability and movement at the camera mounting height.
- K. All of the Outdoor Cameras (Fixed or PTZ) shall be Day / Night type.
- L. The system must have a UPS backup power to run the whole system for not less than one (1) hour in case of power failure.
- M. The system must have a hot standby system with automatic changeover in case of any fatal failure in the active system.

2.3 VIDEO MANAGEMENT SYSTEM SOFTWARE

- A. The IP video management system shall be built upon open, industry standards and facilitate integration with IT infrastructures and other digital and analog systems.
- B. The IP video management system shall provide an API/SDK that is capable of being used at a level consistent with a full-featured gateway. The gateway shall provide an RS232 ASCII interface, Ethernet interface, and the ability to create custom plug-ins to the system user interface.
- C. The IP video management system shall support cameras that generate a standard NSTC/PAL composite video signal.
- D. The IP video management system shall incorporate up-the-coax PTZ camera management technology as well as serial control methodologies.
- E. The IP video management system shall provide support for IP cameras from multiple manufacturers.
- F. The IP video management system shall support standard resolution and megapixel IP cameras.
- G. The IP video management system shall not limit resolution, frame rate, or number of standard-resolution or megapixel cameras that can be recorded, viewed, and managed on the system.
- H. All displays shall retain the camera's aspect ratio and accommodate 4:3, 16:9, or 16:10 monitor displays.

- I. All components of the IP video management system shall be built upon a reliable and robust Linux® operating system except for the Windows® workstation.
- J. The system shall be fully distributed in nature so that each system device can remain operational in a majority of modes without dependence on other devices.
- K. Multiple users shall be able to simultaneously view the same camera view or sequence. The system shall use multicast streaming video to allow multiple users to view the same video stream, though not necessarily synchronized with each other, without affecting the bandwidth of the network.
- L. Video titling shall provide for a 100-character camera site description (on/off), display time/date (on/off), set the display color (black-white), display a site message (on/off), and define the screen block position for the title.
- M. The IP video management system shall have the capability to create and execute a system script used to control and automate any system function. Scripts can be nested such that multiple actions can be taken off the same trigger. The IP video management system shall be capable of the following actions (minimal requirements):
 - 1. Display video from any camera to a specific monitor or screen division, including changing screen division views.
 - 2. Reset any monitor to its original screen division and image.
 - 3. Move system PTZ cameras to a specified preset location.
 - 4. Activate predefined patterns on system PTZ cameras.
 - 5. Start/stop recording an event from any indicated video source.
 - 6. Use script nesting, a means of running another script within any given script.
 - 7. Activate system relays and send an e-mail notification to any recipient through pop3.
 - 8. Add wait times to any script command.
- N. The video management system shall support sequences running on any network monitor. Alarms or user intervention shall be capable of interrupting a running sequence
- O. Operator control of a camera or selection of monitors shall override the sequence control of camera or monitor; sequence control of a camera or selection of monitors shall not override operator control of a camera or selection of monitors.
- P. The IP video management system shall allow for programming of alarms and associated incoming alarms with related parts of the system. Alarms and other triggers can be grouped into system events. System events can be configured using Boolean logic that requires multiple entities to be true before a system event is triggered.

- Q. Individual, group, or all alarms shall be disabled by special sequences, which can be initiated by the operator or automatically by time/day/date.
- R. The IP video management system shall log all alarms and events in the system management database.
- S. The IP video management system shall provide for virtual matrix functionality, leveraging the IP network to switch any camera to any monitor as well as transmit alarms and other system messages to any console on the network.
- T. The IP video management system shall utilize a Management Server to provide user and database management.
- U. The Management Server shall support database Standby Failover when using two servers by maintaining a continuously synchronized duplicate of the main database at all times.
- V. To ensure system security and integrity, the IP video management system shall incorporate a methodology for validating the authenticity of the source of any video or communication message before recording, displaying, or acting on that message. One example of such a methodology is the use of the RSA 256-bit public/private key authentication scheme. All video generated by IP cameras or video encoders shall be digitally signed using the device's public key prior to the content being recorded or displayed by a receiving device.
- W. The IP video security system's digital recording subsystem shall incorporate a distributed, load balancing architecture and provide fault tolerance and redundancy in critical areas of concern. The hardware shall be designed such that all serviceable components can be easily replaced or maintained without the need to take the storage system off line. As a standard, all network storage devices shall provide RAID 6 redundancy to safeguard the data if a hard disk drive failure occurs.
- X. The IP video management system shall provide multilevel diagnostics of each component in all critical areas. These diagnostics shall be reported to a diagnostic console for processing. The diagnostic data shall be capable of being scripted into actionable events within the system. In addition, standard SNMP messages shall be capable of being mined by network diagnostic systems for diagnostic traps and operational data.
- Y. The IP video management system shall support intelligent edge devices for video motion detection and analytics analysis. Motion detection shall allow for the configuration of:
 - 1. Three independently configured groups of activity detection zones.
 - 2. Each zone can be programmed with its own specific sensitivity level and configured for a specified threshold.
 - 3. Video motion shall be capable of enabling motion-based search routines, triggering relays, or executing scripted responses.

- Z. The IP video management system shall be able to handle future expansion of an unlimited total capacity from what is shown in the drawings, including, but not limited to, cameras, monitors, alarm circuits, and relay closures.

2.4 MANAGEMENT SERVER

- A. The system manager shall support database redundancy by utilizing two servers and maintaining constant synchronization between the two servers. In the event of a system manager failure, the hot standby shall assume management responsibilities until the failed unit is restored. No loss of functionality, recording, or monitoring capability shall occur during the failover process.
- B. The system manager shall serve as the security key server for the entire system and manage device registration and message authentication using the RSA 256-bit public/private key system.
- C. The system manager software shall manage user rights and permissions. The system manager shall provide for an unlimited number of system operators with personal identification numbers (PINs) that define priority levels, operator facilities, system roles, and camera and monitor groupings. Cameras, monitors, and other system components can be structured in logical groups and user access to groups or individual elements can be restricted.
- D. The system manager shall be capable of serving as an NTP Server for the entire system. The IP video security system shall be synchronized to an NTP server so that all system components function on the same time basis. The NTP server shall reside within the system, and it shall be capable of being driven by external time sources if needed. All time zone corrections shall be provided in the system automatically.
- E. The system manager shall be capable of performing as a DHCP and UPnP server for the entire system and components. The system manager shall provide all connection and management communications between system devices.
- F. The system manager shall store a database of all user activity, alarms, and device diagnostic errors. Administrators shall have the ability to determine the retention time targeted for the information. All log entries shall be searchable and exportable through the system log window.

2.5 IMAGE STORAGE

- A. Distributed Image Storage shall be provided. A recording compression technique shall be employed for reducing the amount of data storage required. There shall be at least one Network Video Recorder in each Zone.
- B. The storage shall use RAID6 parity across the storage drives to protect recorded data against a hard disk drive failure.
- C. The storage shall be designed for video surveillance recording applications

and encompass Redundant, hot swappable power supply modules

- D. The storage chassis shall be designed for online service and maintenance and cannot be removed from the rack when needing to replace hard disk drives, fans, power supplies, or operating system drives.
- E. The network storage shall use distributed load balancing across other network storage configured in a storage pool and provide automatic network failover from any box to any box. Based on the configuration, it shall be possible to create an N + N failover scheme within the storage pool. The duration of time shall not exceed 90 seconds between the time a unit fails and when its associated cameras become equally distributed onto remaining storages.
- F. The storage manager shall support the recording of MPEG-4, H.264 baseline, H.264 main profile, and H.264 high profile streams from standard resolution and megapixel cameras.
- G. The storage shall support continuous, scheduled, alarm/event (including analytics alarms), motion, and manual recording. Pre- and post-alarm periods shall be programmable up to the total capacity of the system.
- H. The network storage shall support bookmarking and locking/unlocking of video content on the drives.
- I. The network storage shall support privacy tools that allow administrators to establish maximum retention durations for normal, alarm, and locked video.
- J. The storage shall support an intelligent video grooming protocol that can reduce the frame rate of recorded video as the video ages. Administrators shall have the flexibility to determine whether to groom alarm video or leave it at its real-time level.
- K. The storage shall have the ability to reports all diagnostic events, including software status diagnostics to a centralized user interface. In addition, SNMP traps shall be available for monitoring using a third-party SNMP management console.
- L. The storage shall be fully manageable from a remote workstation, including the ability to configure settings and update firmware and software.
- M. Each Local Recording shall have a minimum of 16 Simultaneous feeds to the main control room at 25 frame per second (fps) per camera.
- N. The Image Storage Frame rate shall be sized according to the following table:

Area	Recording Rate During Trading Hours (fps)	Recording Rate out of the Trading Hours (fps)
Public Areas	25	25
Entrances	25	25
Lifts & Escalators	25	25
Entrance to Public Toilets	25	25

Walkways & Access Bridges	25	25
Management Suite	25	25 (when triggered by the camera motion detection)
Reception / Entrance	25	25 (when triggered by the camera motion detection)
Back of House	6	25 (when triggered by the camera motion detection)
Car Park / External	25	25
Roof Tops	6	25 (when triggered by the camera motion detection)
Service Yard	6	25 (when triggered by the camera motion detection)

- O. The Contractor shall size the capacity of each local storage based on the table above, 100% motion, 4 CIF resolution and archiving of 90 days minimum in addition to 20% spare Storage Capacity in each NVR.
- P. Local Storage shall have 2 x 1Gbit 1000Base T RJ-45 Ethernet connections and serial port capabilities to communicate with serial devices.
- Q. Recorded video shall be triggered by the motion detection sensor of the IP camera, an external input device, or in continuous record mode. The Storage shall have the ability to link specific events in an "if-then" scenario. Linked events types shall include video motion, video loss, input trigger, Serial Port and temperature

2.6 PC WORKSTATION

- A. The PC workstation shall use a graphical user interface (GUI) that is compatible with Microsoft® Windows Vista® and a keyboard/mouse for monitoring live and recorded video, virtual matrix functionality that allows operators to see and respond to any alarm from any device on the network, and direct any camera to any monitor on the network.
- B. The PC workstation shall allow administrators to configure devices, set up users, adjust network settings, and create recording schedules. Permission to access these functions and all other system services can be configured to a fine level of detail. The PC workstation shall have advanced search capabilities, event logging, and alarm interface displays. The PC workstation shall export video and still images in multiple formats, including Manufacturer's Native, QuickTime® MPEG-4, H.264, AVI, BMP, and JPG. A front panel USB port and Blu-Ray, DVD/CD-RW drive shall be included to make it capable of exporting video clips and still images to external media. Authentication software shall be exported automatically for any Manufacturer Native exports.
- C. The PC workstation shall allow users with authority to monitor content from standard resolution, megapixel resolution cameras, and encoders throughout the network. The PC workstation shall display content encoded in MPEG-4, H.264 baseline, H.264 main, and H.264 high profile.

- D. The PC workstation shall be capable of decoding up to 16 simultaneous video streams at 4CIF resolution, 30 ips that are encoded in MPEG-4; or 12 simultaneous video streams at 4CIF resolution, 30 ips that are encoded in H.264 baseline profile; or 2 simultaneous 1080p video streams that are encoded in H.264 baseline profile.
- E. The PC workstation shall be capable of minimizing the CPU processing load and network bandwidth required by using a scheme that automatically seeks out and subscribes to a secondary stream at a lower resolution when the display is changed to a multichannel display.
- F. The PC workstation shall support CCTV-style keyboard control of PTZ cameras as well as camera call-up.
- G. The PC workstation shall detect the monitor's native resolution and provide users with a single, 2 x 2, 3 x 3, 4 x 4, 1 + 5, 1 + 12, 2 + 8 for 4:3 aspect ratio monitors and adds 3 x 2 and 4 x 3 displays for 16:9 aspect ratio monitors.
- H. The PC workstation shall retain the camera's aspect ratio and allow for the mixing of standard resolution and megapixel resolution cameras on the same monitor.
- I. The PC workstation shall allow any combination of live or playback video on the same monitor simultaneously. The workstation shall also provide synchronous playback of up to 16 cameras simultaneously.
- J. The PC workstation shall provide for digital zoom capability for any camera in live or playback mode.
- K. The PC workstation shall provide Zones of Interest that can generate several independently controlled and zoomed images from a single image, allowing operators to maintain a panoramic view of the scene while closely monitoring selected areas.
- L. The system shall be capable of customizing the display area to suit user preferences. All aspects of the GUI can be resized, torn-off and moved to other monitors, or hidden. Up to six customizable workspaces can be created and loaded with camera groups to facilitate easy and efficient monitoring. The system shall allow for up to two video display tear-offs accommodating up to a 32-camera display.
- M. The PC workstation shall notify operators of all alarms on the system in a convenient alarm tab. Video thumbnails shall be available for visual verification within the alarm monitoring workspace. Alarms can be acknowledged or snoozed by the operator. The PC workstation application shall support the functionality to view procedures and instructions for given alarms; these procedures shall be triggered to appear during a certain event, and they can be used to provide detailed written or verbal instructions to the operator about actions to be taken. In addition, operators can enter their own feedback to the given alarm. All user alarms and user actions shall be kept in the system log for audit purposes.

- N. The PC workstation application shall support digital zoom on a PTZ camera's live video streams.
- O. The PC workstation application shall provide the ability to control and program any camera equipped with PTZ. The PC workstation shall be capable of the following operations:
 - 1. Manually control the PTZ.
 - 2. Set the pan/tilt home positions for manual or alarm activation.
 - 3. Automatically control the cameras through an alarm trigger.
 - 4. Ability to set multiple preset positions.
 - 5. Ability to set multiple tours.
 - 6. Remotely set and clear the movement limits of the pan/tilt mechanism from the control room, using a telemetry unit at an outdoor camera site.
 - 7. Adjust the zoom lens.
 - 8. The ability to control the camera menu and set up the camera through the IP video security system.

2.7 CAMERAS

- A. The following specifications describe the minimum requirements for the Cameras in terms of resolution, lens, ... etc
- B. the contractor to provide detailed cone of view study based on which the exact specification for each camera to be selected in order to provide clear recognise picture quality.
- C. In general, The camera representation of the object for monitoring should be as follows:
 - 1. For identification purposes – the figure should cover at least 120% of the screen height
 - 2. For recognition purposes – the figure should cover at least 50% of the screen height
 - 3. For detection purposes – the figure should cover at least 10% of the screen height
 - 4. For monitoring purposes – the figure should cover at least 5% of the screen height
 - 5. For number plate recognition, the recommended screen image representation must be at least 50% of the screen height.

2.7.1 IP FIXED INDOOR CAMERA

- A. The camera shall offer dual video streams with megapixel resolution in progressive scan format. The Camera shall support standard IT protocols.
- B. The camera shall be a compact size with a 3" class bubble, shall include a compact indoor enclosure, and come with an integrated varifocal 2.8~10 mm lens.

- C. The camera shall be capable of firmware upgrades through a network using a software-based device utility.
- D. The camera shall provide advanced low-light capabilities with sensitivity down to 0.12 lux in color.
- E. The camera shall support two simultaneous, configurable video streams. H.264, MJPEG, and MPEG-4 compression formats shall also be available for primary and secondary streams with selectable unicast and multicast protocols. The streams shall be configurable in a variety of frame rates and bit rates.
- F. The camera shall support industry standard Power over Ethernet (PoE) IEEE 802.3af to supply power to the camera over the network.
- G. The camera shall use a standard Web browser interface for remote administration and configuration of camera parameters. The browser interface shall support multiscreen remote monitoring for up to 16 cameras on the same virtual local area network (VLAN).
- H. The camera shall have a window blanking feature to conceal user-defined privacy areas that cannot be viewed by an operator. The network camera shall support up to four blanked windows. A blanked area shall appear on the screen as a solid gray window.
- I. The camera shall support open architecture best practices with a published API available to third-party network video recording and management systems.
- J. Network cameras installed in elevators' car should be mini dome type.
- K. The network camera shall meet or exceed the following design and performance specifications.

Imaging Device	CMOS 1/3-inch, effective, Progressive scan
Signal-to-Noise Ratio	50 dB
Auto Iris Lens Type	DC drive
Electronic Shutter Range	1~1/100,000 sec
Wide Dynamic Range	60 dB
White Balance Range	2,000° to 10,000° K
Sensitivity	f/1.2; 2,850K; SNR >24dB 0.50 lux
Color (1x/33ms) Color SENS (15x/500 ms)	0.12 lux

Video Streams	Up to 2 simultaneous streams
Compression	H.264 in base profile, MPEG-4, and MJPEG 800 x 600; 4:3 aspect ratio; 30.0 ips at 2.0 Mbps bit rate for H.264
Max. Resolutions and Frame Rates	800 x 600; 4:3 aspect ratio; 25.0 ips at 5.8 Mbps bit rate for MJPEG 640x480; 4:3 aspect ratio; 30.0 ips at 1.7 Mbps bit rate for MPEG-4
Supported Protocols	TCP/IP, UDP/IP (unicast, multicast IGMP), UPnP, DNS, DHCP, RTP, RTSP, NTP, IPv4/6, SNMP, QoS, HTTP, HTTPS, LDAP (client), SSH, SSL, STMP, FTP, mDNS (Bonjour), and 802.1x (EAP)
Pan/Tilt Adjustment	Pan 355° Tilt 180°

2.7.2 IP FIXED OUTDOOR CAMERA

- D. The camera shall offer dual video streams with megapixel resolution in progressive scan format. The Camera shall support standard IT protocols.
- E. An alarm input and relay output shall be built in for integration with hard wired external sensors.
- F. The camera shall provide a removable, local storage medium (Mini SD) for scheduled and event-based recording of images.
- G. The camera shall be capable of firmware upgrades through a network using a software-based device utility.
- H. The camera shall offer auto back focus (ABF) functionality through a push button on the camera. ABF parameters shall also be configurable through a standard Web browser interface.
- I. The camera shall offer a service port providing NTSC/PAL analog video output signal for adjusting field of view and focus at the camera.
- J. The network camera shall provide advanced low-light capabilities for color and day/night models with sensitivity down to 0.12 lux in color and 0.03 lux in black-white (B-W).
- K. The network camera shall have a removable IR cut filter mechanism for increased sensitivity in low-light installations. The sensitivity of the IR cut filter removal shall be configurable through a Web browser.

- L. The network camera shall support two simultaneous, configurable video streams in H.264, MPEG4 and MJPEG compression formats. The streams shall be configurable in a variety of frame rates and bit rates.
- M. The network camera shall support industry standard Power over Ethernet (PoE) IEEE 802.3af to supply power to the camera over the network. The network camera shall also offer a 24 VAC power input optional use.
- N. The network camera shall use a standard Web browser interface for remote administration and configuration of camera parameters. The browser interface shall support multiscreen remote monitoring for up to 16 cameras on the same virtual local area network (VLAN).
- O. The camera shall have a window blanking feature to conceal user-defined privacy areas that cannot be viewed by an operator. The network camera shall support up to four blanked windows. A blanked area shall appear on the screen as a solid gray window.
- P. The network camera shall support open architecture best practices with a published API available to third-party network video recording and management systems.
- Q. Sufficient lighting arrangement must be provided for the network camera according to the location and requirement.
- R. Sufficient lighting should be provided in the sites of long-range vision to cover the area of surveillance.
- S. The network camera shall meet or exceed the following design and performance specifications.

Imaging Device	CMOS, 1/3-inch, Progressive scan	
Signal-to-Noise Ratio	50 dB	
Auto Iris Lens Type	DC drive	
Electronic Shutter Range	1~1/100,000 sec	
Wide Dynamic Range	60 dB	
White Balance Range	2,000° to 10,000°K	
Sensitivity	f/1.2; 2,850K; SNR >24dB	
	1. Color (1x/33ms)	0.50 lux
	2. Color SENS (15x/500 ms)	0.12 lux
	3. Mono (1x/33ms)	0.25 lux

	4. Mono SENS (15x/500 ms) 0.03 lux
Video Streams	Up to 2 simultaneous streams
Compression	H.264 in base profile, MPEG-4, MJPEG
Max. Resolutions and Frame Rates	1280 x 1024; 5:4 aspect ratio; 20.0 ips using MJPEG and H.264 compressions
Supported Protocols	TCP/IP, UDP/IP (unicast, multicast IGMP), UPnP, DNS, DHCP, RTP, RTSP, NTP, IPv4/6, SNMP, QoS, HTTP, HTTPS, LDAP (client), SSH, SSL, STMP, FTP, mDNS (Bonjour), and 802.1x (EAP)
Input Voltage	24 VAC or PoE (IEEE802.3af class 3)

2.7.3 IP PTZ DOME CAMERA

- A. The camera dome system shall be a discreet camera dome system consisting of a dome drive with a variable speed/high speed pan/tilt drive unit with continuous 360° rotation; 1/4-inch high resolution color, monochrome, or color/black-white CCD camera; motorized zoom lens with optical and digital zoom; auto focus; and a suitable enclosure. The camera shall support standard IT protocols.
- B. Minimum Camera Resolution shall 5 Megapixel.
- C. The camera shall feature open architecture connectivity for third-party software recording solutions allowing integration into virtually any IP-based system.
- D. The dome system shall meet or exceed the following design and performance specifications:

Image Sensor	1/4-inch EXview HAD™ CCD
Lens	f/1.4 (focal length, 3.4~119 mm; 27X optical zoom, 12X digital zoom)
Focus	Automatic with manual override
Sensitivity at 35 IRE	0.55 lux at 1/50 sec (color) 0.018 lux at 1/1.5 sec (color) 0.00018 lux at 1/1.5 sec (B-W)
White Balance	Automatic with manual override
Shutter Speed	1/1.5~1/30,000
Wide Dynamic Range	128X

Ports	RJ-45 for 100Base-TX
Alarm Outputs	2
Auxiliary Outputs	2
Video Encoding	H.264 base profile, MPEG-4, MJPEG
Video Streams	2, simultaneous
Max. Resolution	Upto 4CIF (704x576)
Max. Frame Rate	30fps at 4CIF resolution
Supported Protocols	TCP/IP, UDP/IP (Unicast, Multicast IGMP), UPnP, DNS, DHCP, RTP, RTSP, NTP, IPv4/6, SNMP, QoS, HTTP, HTTPS, LDAP (client), SSH, SSL, SMTP, FTP, mDNS (Bonjour®)
Users	20 simultaneous using unicast; unlimited using multicast H.264 or MPEG-4 802.1x (EAP)
Pan Speed	Variable between 400° per second continuous pan to 0.1° per second
Presets	256 positions with a 20-character label available for each position; configurable camera settings, including selectable auto focus modes, iris level, LowLight™ limit, and backlight compensation for each preset.
Preset Accuracy	± 0.1°
Proportional Pan/Tilt Speed	Speed decreases in proportion to the increasing depth of zoom
Automatic Power Up	User-selectable to the mode of operation; the dome will resume when power is cycled, including an automatic return to position or function before power outage
Zones	8 zones with up to 20-character labeling for each, with the ability to blank the video in the zone
Window Blanking	8, four-sided user-defined shapes
Patterns	8 user-defined configurable patterns including pan/tilt/zoom and preset functions
Scheduler	Internal scheduling system for configuration presets, patterns, window blanks, alarms, and auxiliary functions based on internal clock settings

Azimuth/Elevation/Zoom	On-screen display of pan/tilt locations and zoom ratio
Compass Display	On-screen display of compass heading and user-definable compass setup

2.8 LED MONITORS

- A. The LED monitors shall be of appropriate size to match the viewing requirements of the central Security Room, with Native Resolution 1920 x 1080 and Contrast Ratio 4000:1
- B. The LED monitors will have VGA and digital visual interface (DVI) inputs, picture-in-picture (PIP), looping BNC output, and full high definition resolution.
- C. The LED monitors shall provide a front panel that allows the user to adjust image quality, brightness, size, position, and geometry for optimal viewing.
- D. The LED monitors shall have improved airflow and thermal reduction allowing for longer component life, ensuring reliability in a 24/7 security installation environment.
- E. The LED monitors shall be constructed of a lightweight aluminum frame composition for desktop or wall-mount installations. Stationary and tilt wall mounts shall be available. The monitors shall provide built-in hand holds in the rear cover for easy installation and handling. Coordinate with the Security Console manufacturer for the proper installation accessories of the monitors.
- F. The LED Monitor should be specified by the manufacturer for Video Surveillance application, Residential LED Screen shall not be accepted.
- G. The LED monitors shall the following minimum specifications:
 - a. Native Resolution : 1920 x 1080 Pixels.
 - b. Contrast Ratio : 4000 : 1
 - c. Viewing Angle : 178H / 178V
 - d. Audio : In / Out with Integrated Speakers

2.9 VIDEO WALL

- A. The video wall processor shall have the following specification as a minimum:
 - Scalable video wall processing with up to 16 displays.
 - High speed, dedicated video/graphic bus delivering real time performance.
 - HDMI/DVI/RGB output card supports resolutions up to 1920x1200 and HDTV 1080p/60
 - HDMI/DVI/RGB/HD component input card

- Supports any mix of composite or S-video signals.
- High quality image up scaling and downscaling.
- Easy to use configuration and control software.
- Supports digital and analog input signals up to 1920x1200
- Combines input sources into 2 or 4 windows on a single display

B. The video wall display shall have the following specification as a minimum:

- 46 inch S-PVA TFT with LED backlights
- Very Narrow bezel (zero edge)
- Native resolution 1980x1080
- 700 Cd/m2 max brightness
- 3500:1 contrast ratio
- 8ms response time.
- Built in speakers.
- 1 x D-sub 15 pin; 1 x S-Video; Composite (BNC); RGBHV for analog input for video
- 1 x DVI-D, 1 x HDMI 1.3 for digital input for video
- LAN 100Mbit; remote control wire (3,5mm jack); RS232 for input control
- Composite (BNC) analog output for video
- 1 x Display Port, 1 x DVI-D analog output for video
- Remote control wire (3,5mm jack); RS232 for output control
- LAN with SNMP; RS-232C (9-pin D-sub) Input and Output; Remote Control IR (internal/external (optional) sensor

2.10 HOUSING

2.10.1 INDOOR HOUSING

A. Indoor Camera Housing shall be complete with all necessary installation accessories; Cast aluminum Back Box and decorative Lower Dome, Dome Color to be selected by the Arch. Consultant.

2.10.2 OUTDOOR HOUSING

- A. The housing will be a vandal resistant and environmental camera enclosure offering weather protection to CCTV camera/lens/receiver combinations.
- B. The unit will have a sunshield that will provide protection against UV radiation and corrosion and a latch with a loop for a padlock as standard.
- C. The housing will include a camera power supply; a thermostatically controlled heater and blower to prevent condensation forming in the enclosure.
- D. The housing will have an IP 66 rating.

2.11 SECURITY CONTROL ROOM

- A. Main Control room must have the proper size and space for monitors and operators, ventilation and lightings, access security and alarm system, sufficient power system and the required communication system for local and police authority emergency communications.
- B. The Control room should be operational around the clock throughout the year.
- C. The room should have the required number of personnel to operate, manage and maintain the system as well as the required training.
- D. Three (3) work shifts of eight (8) hours for operators must be performed to maintain the 24x7 round the clock operation.
- E. If there is need, the control room must have a direct hotline connectivity to the National Command Center.
- F. If required, the control room must have a secured connectivity for remote monitoring to the National Command Center.
- G. The Control room must have an electronic security access and a power back up system in case of power failure.
- H. The Control room must have physical protection and safety devices.
- I. For any emergency, the room must have an evacuation plan for the safety of the personnel.
- J. The control room must have proper lighting and ventilation. The room must also be equipped with physical protection and alarms for any external attack and intrusion detection system to prevent unauthorized entry..

PART 3 - EXECUTION

3.1 INSPECTION

The Contractor will provide timely written requirements for the areas and conditions under which the CCTV is to be installed. The Contractor will notify in writing if the conditions are found to be detrimental to proper completion of the work, prior to installation.

3.2 INSTALLATION

- A. Install complete CCTV System, including associated control devices as indicated, in accordance with manufacturer's written instructions, requirements of applicable standards, and in accordance with recognized industry practices to ensure that installation complies with requirements and serves intended function.

- B. Coordinate with other work as necessary to interface installation of CCTV System with other work.

3.3 SERVICE AND MAINTENANCE

- A. The system must have a corrective and preventive maintenance contract or periodical Service Level Agreement (SLA) for its operational life which includes but not limited to the following:
 - 1. Cleaning the equipment
 - 2. Repairing or replacing faulty equipment
 - 3. Fitness for purpose checks
 - 4. Maintaining camera positions and focus
 - 5. Upgrading the system software f) Equipment warranties
 - 6. Maintenance logs and audit report

3.4 FIELD QUALITY CONTROL

- A. Upon completion of installation and after System has been energized, demonstrate capability and compliance of CCTV System with requirements.
- B. Where possible, correct malfunctioning units at site then retest to demonstrate compliance; otherwise, remove and replace with new units, and retest.

3.5 PERSONNEL TRAINING

Building Operating Personnel Training: Train Owner's building personnel in procedures for starting up, bypassing and operating CCTV System. Furnish three paper operator's manuals and one digital copy, providing installation and operation instructions for the CCTV System.

END OF SECTION 25

SECTION 26

ACCESS CONTROL SYSTEM

PART 1- GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions and Division-1 (General requirements), apply to work of this section.
- B. General Provisions for Electrical Work, Section 16010 apply to work of this section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services, tests and operation and maintenance documentation necessary to complete and make ready for operation, Access control System in accordance with Drawings and Specifications.

1.3 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in the manufacture of Access control System of types, ratings, and capacities required, whose products have been in satisfactory use in similar service for not less than 10 years.
- B. Standards Compliance: Comply with requirements of applicable local codes, DIN/VDE, IEC, BS, NEC, UL, NEMA, and NFPA Standards pertaining to the access control system.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's data and installation instructions for Access control System.
- B. Shop Drawings: Submit dimensional layout on architectural background drawings showing all proposed cable routes and setting out of door equipment and conduits.

1.5 EQUIPMENT WARRANTY

- A. Guarantee equipment furnished under these specifications against defective parts and workmanship under terms of the manufacturer's and dealer's standard warranties for a period of not less than one year from date of initial start up and consultant acceptance of the system and include labour and travel time for necessary repairs at the job site.

PART 2- PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

Refer to the attached manufacturer's list.

2.2 GENERAL

- A. All equipment and materials used will be standard components, regularly manufactured and regularly utilized in the manufacturer's system.
- B. All systems and components will have been thoroughly tested and proven in actual use.
- C. All systems and components will be provided with an explicit manufacturer warranty.

2.3 DOOR CONTROLLERS

- A. The quantities and types of door controllers will be determined by the contractor based upon the requirement to provide a fully operational system, as per the intent of the specification, as shown on the drawings and recommended by the manufacturer. As a minimum, the following features will be supported in each Door Controller:
 - 12,000 users per door.
 - Support for 2, 4 and 8 doors per access control panel.
 - Standalone Access Control operation.
 - Real Time Clock/Calendar.
 - Resident Day & Date Based Logic.
 - Central Control and Monitoring.
 - First Entry Auto Unlock.
 - Zoned Anti-Pass back.
 - Multi-Tenant Support.
 - Multi-Drop RS485 Communications.
 - Fibre Optic Compatible.
 - On-Board battery charger.
 - One dedicated tamper input.
 - Support for supervised inputs.
 - Support for proximity and biometrics reader technologies.
 - Minimum 16 alarm inputs.
 - Interlocking
 - TCP/IP Communications.

2.3.1 CONTROLLER OPERATION

- A. Distributed Access Control downloads all "local" access control parameters from the Host PC to the access control panel, so that it may operate in a standalone basis. This ensures rapid access processing and minimal dependence on a single point of failure. As a standalone controller, the access control panel provides access to up to 8 doors.

Support for a door monitor input, locking mechanism output, secondary alarm bypass output, and a request to exit input is provided for each door. Optionally, on each door a second reader may be used for door exiting. When the door is controlled by two readers for entrance and exit, anti-pass back operation is available. As a distributed intelligence network controller, the access control panel allows centralized alarm monitoring, historical data collection, and zoned anti-pass back.

- B. First Entry Auto Unlock allows the door to automatically unlock during the day based upon a time and day profile. However, this feature ensures that the door is not unlocked until at least one "authorized" person has arrived, following occupancy time.

2.3.2 ELECTRICAL SPECIFICATIONS

- Memory: 32k EPROM, 64k ram.
- Buffer: 100 messages, nominal.
- Ram battery backup: on-board ni-cad, rechargeable. maintains ram for 30 days.
- Clock/calendar: crystal controlled, real time.
- Controller: 12v ($\pm 10\%$) dc, 1.2 amps maximum.
- Battery charge current: 2 amps maximum (short circuit), 0.8 amps typical.
- Power supply: 250vac transformer (50/60 Hz $\pm 15\%$), 75 VA maximum.
- Power failure notification: standard, using internal detection logic.
- Controller battery backup – maintenance free, rechargeable.
- Battery capacity: 7Ah, 12vdc for up to four hours of normal operation.
- Operating temperature: 32° to 122°f (0°c to 50°c) without battery backup; 50° to 100°f (10° to 38°c) with sealed lead-acid battery backup.
- Operating humidity: 10% to 80% RH, non condensing.

2.4 ALARM INPUT MODULE

- A. The Conservation Centre will be protected by magnetic door contacts fitted to all external entrances, fire escapes and specific internal doors. Certain internal and external areas will be monitored by passive infrared (PIR) movement detectors providing trap protection in these areas. Certain walls and enclosures will be protected by vibration detectors.
- B. These alarms will all be connected to the access control door controllers and displayed on a graphical user interface (GUI) in the control room. The access control PC will sound on receipt of an alarm until such time as the alarm is acknowledged on the keyboard.
- C. The GUI will respond to alarm activations by indicating the alarm location on a simplified line drawing mimicking the building exterior and interior. The alarm indication will remain until the alarm is acknowledged on the control keyboard. All doors and trap areas will be indicated on the GUI mimic using simple icons.
- D. Doors which are designated for emergency use only will be fitted with flush mount, exit guard local sounders configured to sound locally until reset by key, in addition to providing an alarm to the access control system and mimic as described above.

- E. The alarm modules will be housed within the door controllers, or where required, within a separate, wall mount enclosure. The quantities and types of modules will be determined by the contractor based upon the requirement to provide a fully operational system, as per the intent of the specification, as shown on the drawings and recommended by the manufacturer. As a minimum, the following features will be supported in each alarm input module:
- RS-485 Communications – Multi-Drop.
 - Central Control and Monitoring.
 - 16 Supervised Alarm Inputs – Standard.
 - States of Fault Supervision for each input point: Cut, Short, Open and Closed.
 - Alarm Input Shunting Support.
 - Centralized – Manual Overrides.
 - Fibre Optic Compatible.
 - On-Board Battery Charger
 - Tamper Input
 - TCP/IP Communications.

2.4.1 CONTROLLER OPERATION

- A. The alarm input module provides supervised alarm monitoring functions, from a single microprocessor-based controller. The alarm input module will reside on a network of other alarm input modules, alarm input/output modules and access control modules, all connected to a central control unit. When an input senses a change of state, an alarm is initiated at the central control unit indicating alarm location.

2.4.2 ELECTRICAL SPECIFICATIONS

- buffer: 100 messages, nominal.
- controller: 12v ($\pm 10\%$) dc, 1.2 amps maximum.
- battery charge current: 2 amps maximum (short circuit), 0.6 amps typical.
- power supply: 250vac transformer (50/60 Hz $\pm 15\%$), 40va, maximum.
- power failure notification: standard, using internal detection logic.
- controller battery backup – maintenance free, rechargeable.
- capacity: 7Ah, 12vdc for up to four hours of normal operation
- operating temperature: 32° to 122°F (0°C to 50°C) without battery backup; 50° to 100°F (10° to 38°C) with sealed lead-acid battery backup.
- operating humidity: 10% to 80% RH, non condensing.

2.5 ALARM INPUT/OUTPUT MODULE

- A. The alarm input/output modules will be housed within the door controllers, or where required, within a separate, wall mount enclosure. The quantities and types of alarm input/output module will be determined by the contractor based upon the requirement to provide a fully operational system, as per the intent of the specification, as shown on the drawings and recommended by the manufacturer. As a minimum, the following features will be supported in each alarm input output module:

- RS-485 Communications – Multi-Drop.
- Central Control and Monitoring.
- 8 Supervised Alarm Inputs – Standard.
- 4 States of Fault Supervision: Cut, Short, Open and Closed.
- Eight Multi-Mode Form “C” Outputs: Pulsed, Tracking, Latched.
- Alarm Input Shunting.
- Centralized – Manual Overrides.
- Fibre Optic Compatible.
- On-Board battery charger.
- Tamper input.
- TCP/IP Communications.

2.5.1 CONTROLLER OPERATION

- A. The alarm input/output module provides supervised alarm monitoring and command output functions from a single microprocessor-based controller. The alarm input/output module resides on a network of other alarm input/output modules, access control panels and alarm input modules, all connected to a central control unit. An alarm is initiated at the central control unit indicating alarm location. Accordingly an output relay or a group of output relays may be activated or deactivated.

2.5.2 ELECTRICAL SPECIFICATIONS

- buffer: 100 messages, nominal.
- controller: 12v ($\pm 10\%$) dc, 1.2 amps maximum.
- battery charge current: 2 amps maximum (short circuit), 0.6 amps typical.
- power supply: 250vac transformer (50/60 Hz $\pm 15\%$), 40va, maximum.
- power failure notification: standard, using internal detection logic.
- controller battery backup – maintenance free, rechargeable.
- capacity: 7Ah, 12vdc for up to four hours of normal operation.
- operating temperature: 32° to 122°F (0°C to 50°C) without battery backup; 50° to 100°F (10° to 38°C) with sealed lead-acid battery backup.
- operating humidity: 10% to 80% RH, non condensing.

2.6 PROXIMITY CARD READERS

2.6.1 PROXIMITY READER.

- A. Reader will be sealed in a rugged, weatherproof polycarbonated enclosure, providing reliable performance and a high degree of vandal resistance.
- B. Interface with all existing Weigand protocol access control systems.

Output data in Weigand or Clock and Data format, includes a tamper switch to provide notification of reader tampering.

Recognize card formats up to 137 billion unique codes.

Optional integrated weatherproof keypad, which provides an additional level of security by allowing the use of a personal identification number (PIN).

2.6.2 PROXIMITY CARDS

- A. The proximity cards will be a PVC credit card size, with a punched slot for a strap, clip, or for attachment to a key ring.
- B. The presence of small metal objects such as keys or coins near the card will not alter the code read by the reader or prevent the code from being read by the reader.
- C. The individual card will be coded from a population of at least 134 million unique codes. Cards will be sequentially numbered. The user may specify codes or numbers. Exact replacements for cards which may be lost, damaged or stolen will be available upon request. Cards having the same number will also be available upon request.
- D. Cards may be used interchangeably and will be compatible with all readers in the system, regardless of the reader's physical size or style, and without any code matching or memory devices in the reader.
- E. The card manufacturer will guarantee the availability of additional quantities of cards having the same facility code, for a period of at least eight years.

2.7 DOOR LOCK

- A. All locking devices are to be of the electric type fully coordinated with the doors supplier and, to meet the following requirements as outlined below:
 - Approved by the authority having jurisdiction, including local fire authorities.
 - Where required, will meet with Special Locking Arrangements for Delayed Egress under NFPA-101 Life Safety Code.
 - UL listed.
 - Field adaptable for inswing / outswing doors.
 - Provide a minimum holding force of 1600 pounds per door.
- B. All locking devices utilized on passages providing a main means of egress out of a protected space are to meet the following requirements as outlined below:
 - Approved by the authority having jurisdiction, including local fire authorities.
 - Will meet NFPA 101 Life Safety Code requirements.
 - UL listed.
 - Provided with an adjustable timer from 0-60 seconds.
 - Provide a minimum of 1 No. Form "C" relay contact.
 - Will receive power from the lock power supply.
 - A wall mounted Break-To-Exit (BTE) mechanical rocker switch on the secure side.

2.8 MAGNETIC DOOR SENSOR

- UL Listed.
- 3/4" diameter recessed magnetic contacts with factory installed wire leads, minimum 1 foot long, and 22AWG.
- Self-lock mounting
- Where field conditions prohibit the use of a recessed magnetic contact, surface mounted contacts will be used.
- Operation: normally open/normally closed (NO/NC) volt free magnetic contacts.

2.9 EMERGENCY BREAK GLASS TO EXIT UNIT

- UL Listed.
- 1 No. spare glass.
- Dual pole, NO/NC volt free contacts.
- Both positive and negative lock feeds to be broken when operated.

2.10 SOFTWARE

- A. The system software will be compiled for faster execution speeds and will offer all of the following features and capabilities:

Input/output Capabilities: From any local PC workstation or any remotely connected PC workstation, the system operator will have the capabilities through the keyboard/mouse to request dynamic displays of current values or status using a tabular or graphic format. A global database sort utility will allow an expanded tabular display of only the points on the current graphic display. This expanded tabular display will list point name, hardware address, dynamic state or value, alarm status, override status, and test mode status.

Obtain a summary of all access control doors with status (under access control, access control disabled, or access control ignored) and allow issuing commands to the access control doors to manually force the door to one of the above states, or provide a momentary release (act as a valid key/card access), or return to automatic control (remove manual state).

Add, delete, or change points within each panel/module or application routine while on-line.

Change point I/O descriptors, status, and alarm descriptors and engineering unit descriptors while the system is on-line.

Add new panel/module to the system while the system is on-line.

Develop, modify, delete or display full range of colour graphic displays providing dynamic, animated displays. All development, editing and display work will be capable of being performed with the system fully on-line and in full communications with the panels/modules.

To enhance system response the database will be distributed with up to 24,000 ID records residing in each door processing unit. Each distributed control unit will support a combination of up to 64 sub LAN controllers consisting of access control panels, alarm input units and alarm input output units. Each access control panel will be capable of providing full

access control decision capabilities and monitoring of assigned input/output alarm points whether on or off-line with host computer.

2.11 ID BADGING SYSTEM.

A. GENERAL.

The ID Badging system is to operate over a network where multiple workstations or print stations reside. This system is to enhance the way you can access to existing data source for card production. The software will feature a utility wizard to assist in data base creation or integration where multiple levels / location of data, access and photographs reside. The system will be designed for the museum environment with enhanced security features to allow controlling unlimited levels of access. System server is to store all the card holder's information and design elements. The system uses Microsoft native connectivity to overcome many inherent problems that traditional ODBC connectivity or typical PC data bases cause.

B. FEATURES:

- High speed printing at 144 cards per hour, edge to edge in full color (YMCKO) image printing throughput.
- 300 dpi (11.8 dots per mm.) print resolution.
- 2 MB image memory standard.
- Compatible with Windows 2000, XP and NT 4.0
- Compatible with parallel and serial ports.
- Colour dye sublimation or thermal transfer printing.

System includes Digital Camera, Design Software and PVC Card Printer.

PART 3- EXECUTION

3.1 INSPECTION

- A. The Contractor will provide timely written requirements for the areas and conditions under which the access control system is to be installed. The Contractor will notify in writing if the conditions are found to be detrimental to proper completion of the work, prior to installation.

3.2 INSTALLATION

- A. The contractor will install the access control system, including associated control devices as indicated, in accordance with manufacturer's written instructions, requirements of applicable standards, and in accordance with recognized industry practices to ensure that installation complies with requirements and serves the intended function.
- B. The contractor will coordinate with other works as necessary, to interface the installation of the access control system work with other disciplines.
- C. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing

requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and B.

- D. Anchor mounting hardware firmly to walls, floors, or ceilings, to ensure enclosures are permanently and mechanically secured. Provide all hardware and accessories for proper mounting.
- E. Provide equipment earthing connections for the access control system as required.

3.3 FIELD QUALITY CONTROL

- A. Upon completion of installation and after circuitry and equipments have been energized, the contractor will demonstrate capability and compliance of the access control system with all specified requirements. Where required, the contractor will correct malfunctioning units at site, and then retest to demonstrate compliance; otherwise, remove and replace with new units, and retest.

3.4 PERSONNEL TRAINING

- A. Building Operating Personnel Training: Train Owner's building personnel in procedures for starting up, testing and operating the access control system, intruder detection system and auxiliary equipment. Furnish three paper operator's manuals and one digital copy, providing installation and operating instructions for the access control and intruder detection system.

3.5 DOCUMENTATION

- A. In addition to the training manuals, above, the security Contractor is required to provide two copies, one paper and one electronic, of the handover and commissioning documentation. This documentation will include, but is not limited by, the following.
 - O & M manuals for all products supplied.
 - Trouble shooting guide.
 - Log book for service, maintenance and repairs.
 - As built specification, schematic and drawings.
 - Drawings of any special installations, i.e. not off the shelf.
 - Commissioning documentation to include schedules of cables and loop resistance measurements; schedules of power supplies with on load current and voltage measurements; and details of all back up batteries including capacity and voltage.

3.6 TENDER EVALUATION

- A. All Tender Returns will be evaluated using the following criteria.
 - Cost to supply, install and commission a full and working system.

- Design quality, with special consideration to system integration and robustness.
- Measures taken to minimise false alarms.
- Product selection including quality, reliability and support.
- Cost to provide ongoing maintenance.
- Quality of Service and Maintenance Contract including response times, guarantees, penalties, preventative maintenance.
- Response of referees (referees will only be contacted once a Contractor has been short listed using the above criteria).

END OF SECTION 26

SECTION 27
STRUCTURED CABLING SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions and Division-1 (General requirements), apply to work of this section.
- B. General Provisions for Electrical Work, Section 16010, apply to work of this Section.

1.2 DESCRIPTION OF WORK

- A. Work includes providing all materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner structured cabling system in accordance with Drawings and Specifications.
- B. Any item of equipment or material not specifically addressed on the related drawings or in this document, and which is necessary to provide a complete and functional installation; shall be provided in a level of quality which is consistent with other specified items.
- C. All Cabling, patch cords, fiber connectors and other components shall be from the same approved manufacturer and complied with the active network equipments.
- D. All civil works (i.e. trenches, ducts, hand holes, etc) required to connect between outdoor buildings and control room are part of contractor scope of work
- E. System Tests shall be End to End including the patch cords.

1.3 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in the manufacturing of Structured Cabling System of types and ratings, whose products have been in satisfactory use in a similar service for not less than 10 years.
- B. Standards Compliance: Comply with the latest editions of the requirements of applicable local codes, and the following standards:
 - 1. EIA / TIA-568-A commercial building telecommunications cabling standard (ANSI).
 - 2. EIA / TIA-569 Commercial Building Standard for Telecommunication pathways and spaces (ANSI).
 - 3. EIA/TIA-607 Commercial Building Grounding and Bonding Requirements for Telecommunications (ANSI).

4. EIA/TIA-TSB 67: Transmission performance specifications for field testing of unshielded twisted –pair cabling systems.
5. EIA/TIA – TSB 72 Centralized Optical Fiber Cabling Guide Lines.
6. IEEE 802.3, Ethernet Standards.
7. ISO/IEC11801:2002 Generic Cabling for Customer Premises Standard.
8. UL Subject 444, ANSI / EIA / TIA-606.
9. Telecommunication installation guidelines to comply with the requirements of local authority in Iraq.

If this document and any of the documents listed above are in conflict, then the more stringent requirements shall be applied.

- C. All work must be installed by system manufacturer's certified system installers/vendors who are certified and experienced in implementing the selected data, telephone and IPTV cabling system and to perform related testing programs.

1.4 SUBMITTALS

- A. Product Data: Submit Complete, Detailed, Original Catalogue for the manufacturer and Marked up for all of the proposed equipment.
- B. Detailed Bill of material indicating the model number and quantity for all of the proposed Equipment.
- C. Riser Diagram: Submit detailed riser diagram to indicate the connection between all of The system components and the interface with all other system.
- D. Samples: Submit samples from all materials & accessories included in your proposal.
- E. Compliance list: submit a detailed point by point compliance statement with this specification. Where the proposed system does not comply or accomplish the stated function or specification in a manner different from that described and specified a full description of the deviation shall be provided.
- E. Provide calculations to support the attenuation, bandwidth, number of cores, types of cables and all types of accessories used (if needed).
- F. Provide the testing procedure for UTP cat 6 cables and fiber optic cables. The test procedure should clearly describe the tools and settings which shall be used to ensure correct measurements of the Structured Cabling System.
- G. Shop Drawings
 1. Provide the following item submittals:

- a. Point-to-point wiring diagrams for all cables installed under this Contract.
 - b. Outlet plans indicating all Data, telephone and IPTV outlets and associated ID numbers.
 - c. Cable pull plan, indicating Floor, Location, Cable ID, Patch Panel Port Assignment, Outlet ID
 - d. Detailed plan views and elevations of all telecommunications spaces showing Racks, termination blocks, patch panels, cable paths, etc.
 - e. Drawings to show evidence of coordination with other trades.
3. Acceptance of any submitted data or shop drawings for material, equipment apparatus, devices, arrangement and layout shall not relieve Contractor from responsibility of furnishing same of proper dimensions and weight, capacities, sizes, quantity, quality and installation details to perform efficiently the requirements and intent of the Contract. Such acceptance shall not relieve Contractor from responsibility for errors, omissions or inadequacies of any sort on submitted data or shop drawings.

1.5 EQUIPMENT WARRANTY

- A. The contractor shall provide a clear Warranty Policy to cover the Structured Cabling System.
- B. The system manufacturers shall provide a minimum twenty (20) year warranty on all passive components of the structured cabling system. These warranties shall be provided in written certificate form.
- C. The system manufacturers shall provide in writing to the Owner that in event of the demise or failure of the certified system installer/vendor, the manufacturer shall be responsible for providing another certified system installer/vendor to fulfill the remainder of the warranty conditions.
- D. The Contractor shall provide a guaranteed twenty-four (24) hour x seven (7) days response time to any warranty claims.
- E. All proposed system components (including the patch cords) must be from the same manufacturer to guarantee best performance and end-to-end cat.6/Class E, structured cabling system.

PART 2 - PRODUCTS

2.1 RECOMMENDED MANUFACTURER

Refer to list of recommended manufacturers.

2.2 GENERAL

- A. This section details the manufacturing, supply and delivery to site, erecting, connecting, labeling, testing and commissioning and handing over in working order of a Structured Cabling System.
- B. This cabling system shall function for IP-based Gigabit/10 Gigabit Ethernet serving variety of applications (voice, data, video, etc). The terminology and references in this document as well as the Link/Channel Performance figures for Cat 6/Class E system based on EIA/TIA-568 and ISO/IEC 11801: 2002 cabling standard.
- C. Structured Cabling System which shall include, but not limited to the following:
 - 1. 4 pair UTP Category 6 cables.
 - 2. Fiber optic cables.
 - 3. Cat.6 UTP Patch Panels.
 - 4. Fiber Optic Patch Panels.
 - 5. Cat.6 UTP Patch Cords.
 - 6. Fiber Optic Patch Cords.
 - 7. RJ45, Cat.6 Data outlets.
 - 8. Rack cabinets complete with fans and power strips.
 - 9. Cable management modules, all other cabling and related accessories (connectors, labelling, etc).

2.3 CATEGORY 6 CABLES

- A. All horizontal cat 6 cabling shall be EIA/TIA standards compliant throughout, terminated to 1000BaseT specifications.
- B. All cables shall be high performance 4 pair category 6,UTP UL listed consisting of 23 AWG (0.5 mm²), 100 ohm characteristic impedance, low smoke zero halogen (LSZH) - flame retardant, solid conductors formed into four individually twisted pairs and enclosed by a LSZH flame retardant jacket. Cables shall be laid inside the existing metal conduits and metal cable trunk as indicated on drawings.
- C. Cables shall be run from the user outlet to the IT room racks (as indicated on the drawings) without any transition points.

- D. All UTP cabling must be tested using a level III field tester by the supplier and full documentation must be provided to demonstrate that the cabling meets the industry standards (i.e. IEEE 802.3, EIA/TIA 568 – B.2-1, EIA/TIA 569-A).
- E. Category 6 defines four-wire twisted –pair UTP copper cables that can transmit data and proven support for 100 Mbps fast Ethernet, 250 MHz Broadband Video and Gigabit Ethernet 1000BASE-T.
- F. The Cat 6 cable should be of low–capacitance and exhibits low crosstalk. However, all figures of the cable must be Category 6 compliant.
- G. The cables short term bending radius is 6 times the cable diameter in operation and 10 times the cable diameter in installation.

2.4 SINGLE-MODE FIBER OPTIC CABLES

- A. Single Mode Fiber Optic Cable shall meet or exceed numerous standards for optical fibre, including ITU-TG.652 (Categories A, B, C and D), EN 50173, IEC 60793-1, ISO/IEC 24072 and TIA-492CAAA.
- B. The cable shall be suitable to be used within buildings and outdoor environments for transitional aerial and duct applications, and in entrance facilities that require low smoke zero halogen (LSZH) rated cable.
- C. All-dielectric cable construction requires no grounding or bonding
- D. Dry water-blocking technology allows rapid cable preparation and termination for lower termination costs and time (no messy gel required)
- E. Low smoke zero halogen (LSZH) rated jacket meets IEC 60332-1, IEC 61034, and IEC 60754-2 for standards compliant safety
- F. Sheath markings provide positive identification, quality traceability, and length verification
- G. 250µm buffer coating protects fibres during handling and allows for ease of stripping
- H. The Cable shall be 8.3µm / 125µm with Cladding Non-Circularity: $\leq 1\%$
- I. Attenuation: 1310nm: $\leq 0.39\text{dB/km}$, 1310 – 1625nm: $\leq 0.34\text{dB/km}$ and 1550nm: $\leq 0.25\text{dB/km}$

2.5 RJ-45, CAT.6 OUTLET

- A. The outlet shall be category 6, eight - position angled RJ-45, T568B pinned and modules mounted within the service floor outlet box or on wall flush mounting. The cabling contractor should coordinate with the electrical contractor to ensure compliance and matching between the RJ-45 data connectors with the floor boxes and face plates (information about electrical contractor shall be provided upon request).

- B. The presentation of the outlets shall be provided for labeling and identification. The outlet shall be complete with a transparent window to protect the labeling tag.
- C. All conductors of the 4-pair cat 6 horizontal cable shall be terminated on the respective contacts. To avoid installation errors, the wire organizer of the snap-in connector should be identified by the same standard color coding as the cat 6 cable wires.
- D. Each connector shall provide both T-568A and T-568B color code identification for the pins at the rear of the connector. The punched down should be in accordance with the T-568B color code.
- E. Each outlet to receive one 4 pair cable. Submit sample of the socket for review and approval.

2.6 CAT.6 COPPER PATCH PANEL

- A. All cat 6 data cables shall be terminated on Cat 6 patch panels which shall be rack mounted type.
- B. The presentation of the patch panel shall be provided for labeling using printed numbering system.
- C. The cat 6 patch panel shall provide both T-568A and T-568B color code identification for the pins at the rear of the panel. The punch down is to be in accordance with the T-568B color code.
- D. All conductors from the 4 pair cable should be terminated on the respective contacts. To avoid installation errors, the wire organizer of the snap-in connector must be identified by the same standard color coding as the wires of cat 6 cables.
- E. Each patch panel shall be provided complete with a holder to locate and clamp the incoming cables without causing damage to the cable or affecting the performance of the link.
- F. In the rack cabinet, the patch panels shall be separated by metallic patch-guides to protect the patch cords. The height of these guides shall be 1HU or 2HU depending on the rack space.
- G. The patch panel shall have a sliding mechanism to allow fast and easy termination from the front of the rack cabinet.

2.7 CAT.6 COPPER PATCH CORDS

- A. A low smoke zero halogen – flame retardant CAT.6 copper patch cord shall be provided to connect between the patch panels and switches. Number of cat 6 copper patch cords for each IT room rack shall be equal to the number of outlets served by this rack.
- B. The length of the patch cord to be determined by the contractor based on the arrangement of the equipment inside the rack, but in any case it shall not be less than 2m.

- C. The characteristic impedance of the pairs must be identical to that of the horizontal cat 6 cables.
- D. The patch cords shall have a guaranteed performance level of greater than 750 insertions, without degradation to the performance level of the solution.

2.8 FIBER OPTIC PATCH PANELS

- A. Fiber optic patch panels shall be rack mounted with 24/12 / 8 /4 duplex / modular ports and shall take no more than one unit of vertical space on the rack.
- B. The patch panel shall be equipped with a mechanism that ensures the retention and support of the incoming fiber optic cables.
- C. The patch panel shall be designed with a sliding mechanism enabling front side installation and maintenance work to be carried out without having to remove the entire panel. The patch panel shall be delivered complete with top cover.
- D. The patch panel shall provide facilities to recess the front connector plate deeper than the front of the 19" rails of the cabinet. This will provide sufficient bend radius for the patch cords once connected to the panel. This shall also prevent damage to the patch cords when the cabinet door is closed.
- E. Use pigtails for termination of all fiber optic cables to fiber optic patch panels. The patch panel shall provide management for 1 m of fiber per link after breaking the fibres out from the cable.
- F. Cable management unit shall be provided with the fiber optic patch panel.

2.9 FIBER OPTIC PATCH CORDS

- A. All needed fibre optic patch cords shall be provided to connect between the fiber optic patch panels and the active equipment. The length of the patch cord to be determined by the contractor based on the arrangement of the equipment inside the rack (s).
- B. Connectors to comply with specifications of TIA/EIA: LC connectors.
- C. The fibre optic patch cord shall be manufactured from LSZH–flame retardant jacket. The fiber optic connectors shall comply with IEC 74-13.

2.10 EQUIPMENT / PATCHING RACKS

The contractor shall provide the following equipment racks as follows:

- A. 4/6/42/21/ U rack cabinet (60x60 cm) with front Plexiglas door for LAN services requirement, complete with all required mounting hardware, label kits, silent type ventilation fans, Velcro style fasteners and all needed ancillary devices.

- B. Rack shall be complete with side panels' lockable glass front access door and lockable rear metal door; the rack shall be able to support cable entrance from both top and base.
- C. Each rack shall have a 220V power distribution strip unit rack mounted at each side and complete with a minimum of ten outlets, fuses and power indicator. Provide adequate cable management facilities within the racks to support the cables and ensure that cables are properly secured to prevent stress.
- D. Adequate air flow within rack is required to maintain the expected levels of equipment to be located within each rack; therefore fan assemblies are to be supplied.
- E. The contractor shall provide all necessary cable management units, brackets, required accessories and labeling required for complete installation.
- F. The rack shall be equipped for electrical grounding to meet EIA/TIA 606 tables with fans and power strip unit.

2.11 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with the requirements of the Contract Documents provide products by one of the following manufactures:

- 1. Systimax/ Commscope.
- 2. AMP – Tyco.
- 3. Panduit.
- 4. 3M.
- 5. Brand-Rex.

PART 3 - EXECUTION

3.1 CABLE INSTALLATION

- A. Plan and install all structured cabling systems in accordance with the cable manufacturer's recommendations. Label and record all data communication cables in accordance with:
 - 1. Cable Schedules.
 - 2. Cable Drawings.
- B. Install optical fiber cables in accordance with BS 7718 and all other standards.
- C. Handle, store and install equipment and components of the structured cabling systems in accordance with the manufacturer's recommendations.
- D. Obtain all equipment and components from a single source unless otherwise instructed.

- E. Inspect all equipment and components on delivery, before fixing and after installation and reject and replace any which are defective.
- F. All cables must be installed without splices or cuts to ensure the elimination of reflections, discontinuities, impedance mismatches, etc.
- G. The maximum horizontal length from the outlet to patch panels shall not exceed 90 m. If such case exists, the installer shall inform the owner representative officially to seek an alternative path.
- H. Wiring shall be mechanically protected by cable trucking.

I. PENETRATION THROUGH FIREWALLS -

A conduit sleeve shall be provided where horizontal cables penetrate firewalls. The conduit sleeve shall be sized at 40 % fill ratio with a plastic bushing at both ends. After the conduit sleeve is installed the opening around the conduit shall be filled with fire stop and smoke seal materials.

- J. Separation of data communication cables from sources of electromagnetic interference all data communication cables shall be separated from sources of electromagnetic radiation in accordance with TIA standard proposal SP-2072 and the following:
 - 1. If both data and small power cables (2 KVA power circuits) are installed in grounded, ferrous metal conduit throughout their run, then no separation is required (i.e. EMT conduit).
 - 2. FT-6 rated data cabling with no metallic raceway and power conductors (2 KVA power circuits) in a grounded raceway requires 125 mm clearance.
 - 3. For fluorescent luminaries, the required clearance is 300 mm.
 - 4. Clearance increases up to 600 mm for power circuits over 5 KVA.
 - 5. For large motor, transformers, power panels, etc., the required clearance is 1 m.
 - 6. Cables must be routed to avoid direct contact with steam piping, hot water piping or other heat sources to avoid thermal degradation.

If such case exists, the installer shall inform the owner representative officially to seek an alternative path.

- K. All cables, components and items of equipment are to be fully marked with positively fixed labeling devices to facilitate identification. As a minimum requirement, cables are to be labeled at the following points:
 - 1. User end cable/connection.
 - 2. Equipment room end cable/connection.
 - 3. Patch panel connection.

Identification shall include user outlet number, floor number, location & service. Final numbering scheme is to be approved by the owner prior to installation.

The contractor shall submit a marking system for approval by the owner.

- L. The installer must avoid any risk of cable pinching or compression during the installation and termination of the cable. A Velcro cable ties should be used.

3.2 CAT 6 CABLE TESTING AND SYSTEM CERTIFICATION

- A. The structured data cabling system certification shall include 100% cable testing and verification according to the standard.
- B. The verification of each cable shall be performed by the contractor and shall be documented on a cable testing sheet which shall form part of the hard/soft copy documentation supplied at the end of the installation.
- C. Use Fluke Test
- D. Testing Procedures

Testing shall include, but not be limited to, the following:

1. Pair length
2. DC loop resistance per pair
3. Insertion Loss (Attenuation) per pair
4. Near End Crosstalk (NEXT) and Powersum NEXT for every pair combination
5. Far End Crosstalk (FEXT) and Powersum FEXT for every pair combination
6. ELFEXT and Powersum ELFEXT
7. Return Loss (impedance match, retransmitted signal)
8. Pair continuity (Wiremap) including end-to-end continuity, opens, short and polarity
9. Propagation Delay & Delay Skew
10. Powersum cross talk

Any cable not passing the testing procedure shall be replaced in its entirety. No splicing is permitted in the repair of any defective cable.

3.3 FIBER OPTIC CABLES TESTING

- A. Each strand of fiber optic cables shall be tested with real transmission testing with a light source and a power meter according to ISO/IEC14763-2 and ISO 11801:2002 for length and attenuation. Performance test must be below the total loss budget for the cable connectors.
- B. Provide a hard/soft copy chart recording with the test documentation.
- C. Use OTDR and Power meter.

3.4 CABLE TESTER

- A. The cable tester shall provide cable testing and certification solution for high-speed MTP Cat 6 cables and fiber networks. The tester shall also have the capability to monitor network traffic.
- B. Tester should provide at least the following functionalities:
 - 1. Supported tests:
 - a. All cat.6 UTP copper cables parameters mentioned above.
 - b. Single/Multi mode fiber testing
 - c. Attenuation and losses
 - 2. Traffic monitoring
 - 3. Integration with cable management system for cable ID download, test results upload for reporting and all other functionalities
 - 4. Integration with labeling system (calibration tool kit to be provided)

3.5 INSTALLATION OF RACKS

- A. Provide rack cabinets where shown on drawings and secure to wall/floor/ceiling; as equipped.
- B. In locations where more than one rack is required, provide wiring channel inter-connection such that wiring from rack to another is not exposed.
- C. For all racks, coordinate with the site raceways for all cabling extending down from ceiling, such that wiring is not exposed. Secure channel to rack and ceiling.
- D. All wiring shall be run neatly bundled with wiring management channels.
- E. Properly ground racks and equipment to room ground bus.

3.6 OTHER INSTALLATION GUIDELINES

- A. All installation shall be done in conformance with EIA/TIA 568B standards and BICSI Design and Installation guidelines. The vendor shall ensure that:
 - 1. The maximum pulling tensions of the specified distribution Cables are not exceeded and cable bends maintain the proper radius during the placement of the facilities. Failure to follow the appropriate guidelines will require the Vendor to provide in a timely fashion the additional material and labour necessary to properly rectify the situation. This shall also apply to any and all damages sustained to the cables by the Vendor during the implementation.

2. BONDING AND GROUNDING

The vendor shall be responsible for providing an approved ground at all newly installed distribution frames. The vendor shall also be responsible for ensuring ground continuity by properly bonding all appropriate cabling, closures, cabinets, service boxes, and framework. All grounds shall consist of #6 AWG copper wire and shall be bonded to the main electrical ground.

Grounding must be in accordance with the NEC, NFPA codes and practices.

3. POWER SEPARATION

The vendor shall not place any distribution cabling alongside power lines, or share the same conduit, channel or sleeve with electrical apparatus.

4. MISCELLANEOUS EQUIPMENT

The vendor shall provide any necessary screws, anchors, clamps, tie wraps, and distribution rings, wire moulding, miscellaneous grounding and support hardware, etc; which is necessary to facilitate the installation of the System.

5. SPECIAL EQUIPMENT AND TOOLS

It shall be the responsibility of the Vendor to furnish any special installation equipment or tools necessary to properly complete the System. This may include, but is not limited to, tools for terminating cables, testing and splicing equipment for copper/fiber cables, communication devices, jack stands for cable reels, or cable wenchers.

6. LABELING

The vendor shall be responsible for printed labels for all cables and cords, distribution frames, and outlet locations, according to MIS specifications at the time of delivery. No labels are to be written by hand.

- a) All cables, patch panels, patch cords and sockets must be labeled using legible and permanent labels.
- b) Each cable must be permanently identified and labeled at both ends (few centimetres from the termination).
- c) The faceplates labeling should be done using industrial application material to ensure that it neither fade or be removed easily.
- d) Patch panel ports shall be identified in simple numeric form. Patch cords shall be identified at both ends in simple numeric form, not necessarily corresponding to port numbers.
- e) All cable and outlets identification shall be recorded as a hard and soft copy "CABLE IDENTIFICATION LOG"; which is to be handed over to the Owner after cable testing and certification is complete.
- f) Provide samples of the labeling accessories for approval.
- g) Full labeling solution to be provided including software, hardware, portable labeling tool and enough quantity of empty label.

END OF SECTION 27

SECTION 28
IP PUBLIC ADDRESS SYSTEM

PART 1: GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Special Conditions apply to work of this section.
- B. General Provisions for Electrical Work, Section 16010 applies to work of this section.

1.2 DESCRIPTION OF WORK

- A. Supply, install, test and commission all IP-Based Public Address System equipment, accessories and materials complete and in strict compliance with the specification and the drawings. All work shall be carried out in accordance with internationally accepted standards and practices.
- B. Work includes providing all materials, equipment, accessories, services and tests necessary to complete and make ready for operation in accordance with Drawings and Specifications.
- C. Work also includes inspection, alignment and final adjustment of completed installation, demonstration for acceptance and instruction of operating personnel.
- D. The drawings issued with the specification indicate the approximate location of all apparatus. The exact and final location shall be subject to the prior approval of the Engineer.
- E. Coordination with other trades of adjoining and related work.
- F. Provide with the tender a schedule of all equipment to be supplied with a recommended layout of the system.
- G. The contractor shall forward his compliance statement with this specification item by item and any section that he wishes to amend or cannot comply with, shall be clearly defined.
- I. Any item of equipment or material not specifically addressed on the drawings or in this document and required to provide a complete and functional installation shall be provided in a level of quality consistent with other specified items.

1.3 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in the manufacture of IP Public Address System of types, and capacities required, whose products have been in satisfactory use in similar service in similar projects for not less than 5 years.
- B. Standards Compliance: Comply with requirements of applicable local codes, DIN/VDE, IEC.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's data and installation instructions for audio visual systems.
- B. Riser diagram: Submit riser and block diagrams for the IP Public Address System indicating type of different components in the system and also the arrangement of the central equipment inside the rack cabinets.
- C. Power requirements and heat dissipation data for the equipment inside IT rooms and Main Security Room.
- D. An Acoustic Simulation using EASE 4.1 Program or any other specialized program for the following areas:
 - 5 samples of Public Areas/Corridors.
 - 3 Samples of the Gym. and Parking Areas.

The study must show the following figures (measured at 500 Hz, 1 KHz and 2 KHz):

- Direct SPL.
 - Total SPL.
 - RASTI.
 - % ALcons.
- E. Compliance List: submit a detailed point by point compliance statement with this specification. Where the proposed system does not comply or accomplish the stated function or specification in a manner different from that described and specified, a full description of the deviation shall be provided.

Where a full description is not provided it shall be assumed that the proposed system does not comply with the requirements in the specification.

1.5 EQUIPMENT WARRANTY

- A. Guarantee equipment furnished under these specifications against defective parts and workmanship under terms of the manufacturer's and dealer's standard warranties for a period of not less than two years from date of initial start-up and Engineer acceptance of the system and include labor and travel time for necessary repairs at the job site.

PART 2: PRODUCTS

2.1 REQUIRED FEATURES

- A. The equipment of each system shall be stacked in racking with front panel fastening and latitudinal chassis support elements. The design shall be such that all units may be drawn out from the front of the rack and internal connections shall be long enough to permit withdrawal without prior disconnection.

- B. Electrical connections other than those of low level signal shall be effected by means of soldering push-on space clips or multi-connector blocks. Low level signal wiring shall be of heavily braided screened cable sheathed in PVC and connections as recommended by the manufacturer. Output lines within the rack shall be run as twisted pairs heavily screened with tinned copper braid and sheathed with PVC.
- C. Each active item of equipment shall have its own power supply circuit, be independently fused on the live conductor and bear a front panel mains indicator light ON/OFF switch and standard cartridge type fuse holder. A permanent inscription shall indicate the fuse rating.
- D. Positive electric contact shall be made between each equipment and the main racking assembly. The racks shall be independently earthed and it is the responsibility of the contractor to ensure that hum producing earth return loops are avoided.
- E. Audio power amplifiers output shall be tested and rated in accordance with the I.E.C. Standard and 100 V line matching techniques shall be used.
- F. All equipment shall be designed for a continuous trouble-free operation in the climatic conditions of the site.
- G. All components and equipment shall be in full compliance with I.E.C safety regulations and be proofed against tropical conditions.
- H. All units of the system shall be protected from the normal hazards of operation such as mismatch, over-load, short- circuiting of output and connection mistakes etc.
- I. All items of equipment shall under any normal circumstances of operation be capable of withstanding any surges which might be produced by sudden re-establishment of mains or standby power supplied after a power failure.
- J. Heat limits as specified and guaranteed by the manufacturer shall under no circumstances be exceeded. louvers and vents shall be provided to this effect.
- L. Performance requirements
 - 1. Certain overall performance requirements of each sound amplification system shall be checked by measurement. Each system as designed shall meet the following requirements based upon available data and the manufacturer's published specifications. The contractor shall be responsible for use of the equipment specified in the manner specified, and each component's conformance with its manufacturer's specifications.
 - 2. Overall system frequency response shall be +/- 3dB, 125-16,000 Hz when measured in 1/3 octave bands at any location Frequency response shall be measured using time delay spectrometry or a 1/3 octave Real Time Analyzer.
 - 3. The sound levels shall be measured at 1.5 m above floor level (1m above floor level in seating areas) in all normally-accessible areas, using a sound level meter complying with I.E.C 651Type 1or 2, set to 'S' (slow) response and calibrated immediately before the measurements shall be witnessed by the Owner's Authorized Representative who will be provided with a written set

of results. The sound pressure level shall be $88 \pm 2\text{dB}$ and the sound transmission index (STI) shall be > 0.6 at least 75 % of floor area.

2.2 SYSTEM OUTLINE

- A. Provide an IP-Based Public Address System to cover all corridors, public areas and lift lobbies as shown on the drawings.
- B. The IP Public Address System shall be interfaced with the Fire Alarm System so that in case of fire alarm reporting in a certain floor(s), the Public Address loudspeakers of this floor(s) shall be muted.

2.3 COMPACT DISC PLAYER

- A. A rack mounted compact disc (CD) player shall be provided for intensive professional use with constant, day-long operation with the ability to Play MP3 Media
- B. The CD player shall provide the following minimum facilities:
 - i) CD with capacity of 5 discs.
 - ii) Continuous repeat of a pre-programmed track selection
 - iii) Latching pause control
 - iv) Visible display of track number and of total playing time on the inserted disc.
- C. The CD player shall include a cartridge for pre-loading of 5 compact discs, with random track selection facilities.
- D. The CD player shall provide the following minimum performance:
 - i) Frequency response $20\text{Hz} - 20\text{ KHz} \pm 0.5\text{dB}$
 - ii) Signal-to-noise (S/N) ratio $> 100\text{dB(A)}$
 - iii) Channel separation $> 85\text{dB}$
 - iv) Harmonic distortion $< 0.01\% @ 1\text{ KHz}$.

2.4 DVD PLAYER

- A. The DVD player shall utilize the latest technology in the video and audio processor.
- B. The audio D/A converter shall be 24-bit 96 kHz with DOLBY digital and DTS digital output.
- C. The video D/A converter shall utilize 27 MHz, 10-bit technology. It shall be possible to read all DVD zones on the same player.

D. The DVD player shall have at least the following specifications:

- Frequency response : 2 Hz to 20 KHz
- Dynamic range : 106 dB
- Signal to noise ratio : 115 dB
- Total harmonic : 0.0025%

E. The DVD player shall support the following Playback formats:

SACD Super Audio CD Stereo / Multi-channel.

CD Audio

CD – R / RW

DVD Video

DVD – R / RW

DVD + R

F. The DVD player shall have at least 8 MB Buffer Memory for fast layer change.

2.5 AM / FM RADIO TUNER

- A. The AM / FM radio tuner shall have high sensitivity reception performance and clear sound.
- B. The unit shall be equipped with a dot matrix display, rotary knob, up / down tuning & search and 40 stations random preset memory.
- C. A Professional type AM/FM antenna shall be provided with the tuner.
The antenna shall be installed on building roof.
- D. The AM / FM tuner shall have at least the following specifications:
 - Tuning frequency : 87.5 MHz - 108 MHz (FM)
522 KHz - 1611 KHz (AM)
 - Signal to noise ratio : Mono 82 dB, Stereo 78 dB (FM)
53 dB (AM)
 - Frequency response : 20 Hz - 15 KHz (+ 0.5, - 1.0 dB)

2.6 AUDIO SWITCHING MATRIX

- A. A microprocessor controlled, modular audio switching matrix shall be provided to assign any audio input source to a designated any audio outputs, with the required priorities between inputs.

- B. The audio switching matrix shall have at least 8 audio inputs for sound sources and 16 audio outputs to feed the loudspeakers zones as indicated on drawings.
- C. The audio switching matrix shall have at least 24 control inputs and 12 control outputs (free voltage dry closures).
- D. The audio switching matrix shall be of a modular construction and can be extended up to 16 audio inputs and 24 audio outputs.
- E. The audio switching matrix shall be provided with the software with facility of easy programming / reprogramming and operation of all matrix functions (e.g. programmed priorities, fade-in, fade out, routing pattern...etc). All commands of programming and operation shall be displayed on LCD.
- F. The audio switching matrix shall have automatic self diagnostic function which shall be appeared on the LCD display.
- G. The audio switching matrix shall be interfaced with fire alarm system to mute the Public address area/zone related to the alarmed area/zone.
- H. The audio switching matrix shall have at least the following minimum performance:
 - Frequency response : 20-20000 Hz (± 0.5 dB)
 - Distortion : Less than 0.1 %
 - Noise level : 85 dB below rated output
 - Output level : 0Bm line level (0.775 V), max. 14 dBm
 - Output impedance : < 600 ohm
 - Management interface : Via optional Host PC

2.7 GRAPHIC EQUALIZER

- A. The graphic equalizer shall be 1/3 octave, 30 bands centered at ISO standard frequencies.
- B. The equalizer shall be " Fail - safe ", i.e the signal path shall automatically bypass the equalizer in the event of failure of power supply to the unit.
- C. The graphic equalizer shall have at least the following specifications:
 - Frequency response : 20 Hz to 20 kHz (+ 0 / - 0.5, dB)
 - Total harmonic distortion : < 0.01 %
 - Hum and noise : < -88 dB

2.8 AUDIO IP ENCODER / DECODER

- A. The IP Audio Encoders shall be rack mountable type and shall be provided

in the main equipment racks located at the main security room to convert the Matrix audio outputs into Ethernet IP packets to be carried over the Ethernet IP Network as shown on drawings.

- B. On the other hand, the audio IP Audio Decoders shall be provided in the IT rooms to retrieve the audio signal again from the Ethernet IP Network as shown on drawings.
- C. The audio IP Audio Encoders / Decoder shall have a minimum network delay, no more than 1 m sec. and shall be able to transmit unicast, multicast and broadcast packets without any signal degradation.
- D. The audio IP Encoders / Decoder shall be complete with its management software which shall be with GUI menus to enhance ease of use.
- F. All parameters and functions of the IP Audio Encoders / Decoder shall be easily controlled and configured remotely from any PC on the Ethernet network.
- G. The IP Audio Encoders / Decoder shall send and retrieve both audio signal as well as contact closure control signal via the Ethernet IP Network.
- H. The IP Audio Encoders / Decoder shall be multicast capable to allow transmission of audio signal up to 64 locations simultaneously.
- H. UTP Cat 6 Patch panel and RJ-45 cat 6 patch cords shall be provided to connect the IP Audio Encoder/Decoder to the Ethernet IP Network.
- I. The IP Audio Encoders / Decoder shall have the following minimum requirements:
 - Audio input : 1 channel - 40 dB to 0 dB Balanced audio input , 600 ohm
 - Audio output : 1 channel - 40 dB to 0 dB Balanced audio output , 600 ohm
 - Frequency response : 30 – 15 KHz (± 3 dB)
 - THD : < 0.1 % at 1 KHz
 - Control input : 4 contact closure, 30VDC & 50 mA
 - Control output : 4 contact closure, 30VDC & 50 mA
 - LAN : 10BaseT/100BaseTX
 - Network Protocol : TCP, UDP over IP
 - Audio Packet : Unicast – up to 4 simultaneous transmissions
 - Transmission system : Multicast–up to 64 simultaneous transmissions

2.9 MONITOR PANEL

- A. A monitor panel shall be provided to monitor the audio matrix inputs and outputs. The unit shall contain selector switch, integral loudspeaker and calibrated loudspeaker gain control shall be provided.
- B. The output of the monitor loudspeaker shall be muted when a microphone in the same room is in use.

- C. Visual monitoring with a VU meter shall be provided on the monitor panel.

2.10 AUDIO PATCH PANELS

- A. Combining networks and pads shall be provided as required. They shall be 1/2 W, 5% composition resistors soldered fixed connection points at each end. Values for pads may vary slightly depending upon signal levels encountered.
- B. Patch panels shall be labeled with descriptive legend fixed to the blank space between panels. Numerical legend will not be accepted.
- C. Audio Cords shall be provided to connect the inputs and outputs of the audio patch panel. The number of audio cords shall equal the number of patch panel ports.

2.11 RACK CABINET

- A. A standard 19 inch rack cabinet, as detailed in BS 5954, shall be provided to house the central equipment. Provide 20% spare space in each rack for future extension.
- B. The rack cabinet shall be equipped with 4 Nos. silent type blower units and lockable plexi-glass door.
- C. Equipment shall be installed within the rack in a logical (signal path) sequence, i.e. equipment requiring routing operation (e.g. cassette player and monitor panels) shall be located at a convenient working height. Equipment requiring internal access during commissioning and/or routine testing shall be installed on rack runners. The equipment shall remain fully operational when extended on the runners.
- D. Items requiring routine operation shall, where practicable, be installed within the same cabinet.
- E. Unused rack space shall be fitted with blank and perforated panels.
- E. All mains terminals shall be shielded and isolated from inadvertent touch.

2.12 POWER CONDITIONER PANEL

- A. The function of this panel is to distribute the incoming mains supply to the various items of equipment contained in the metal rack and to provide protection against wiring failure or other short-circuit or overload. Also, the unit shall eliminate the ripples and spikes which may be found in the mains supply.
- B. The panel shall be fed directly from one phase of the normal power supply. The main switch shall be of the heavy duty type rated at least 1.5 times the calculated maximum current consumption of the system.
- C. The panel shall be lockable by key in either ON or OFF position and shall feed directly through one main fuse. The fuse shall be of the front panel mounting type with blown indicator lamp and shall be rated in accordance with the regulations.

- D. Distribution shall be effected by means of heavy duty porcelain or plastic mounted brass screw type connectors secured firmly on the base of the panel. Each termination shall be labeled with the equipment item served.

2.13 IP-BASED ZONE PAGING MICROPHONE

- A. IP-Based zone paging microphones shall be provided. The microphone shall be used for general routine paging to all public address zones (separate zone paging, group of zones or all-call paging) as well as to achieve administration and fully function operation of all Public Address System components.
- B. The IP-Based zone paging microphone shall comprise the following components:
- High quantity gooseneck microphone.
 - Preamplifier
 - "ZONES" and "ALLCALL" select keys
 - IP audio encoder
 - All needed software
 - Power Supply
 - RJ 45 – RJ45 UTP Cat 6 cord for connection with Ethernet IP Network.
- C. The IP-Based zone paging microphone shall be connected to the IP Public Address System remotely via the Ethernet IP Network.
- D. The following control functions shall be achieved via the IP-Based zone paging microphone:
- "Zone paging" buttons.
 - "All Call Paging" button.
 - "TALK" button (associated with chime tone).
 - An audible and visible pre-announcement chime indicator, to prevent premature speaking.
 - Selection of background music program broadcasted to each zone.
 - Selection of the audio signal level for each zone.
 - Visual indication (self-illuminated indication) of which background music source has been selected.
 - A green indication annotated "PA AVAILABLE" which shall be illuminated when the system is available for use.
 - A yellow indication, annotated "PA FAULT", which shall be illuminated in the event of a system fault.
 - "BUSY" indicator lamp or LED associated with each zone. This indicator shall be illuminated when another signal (excluding background music) is broadcasted into pre-selected zone or zones.
- D. IP-Based zone paging microphone shall operate as follows:

Upon pressing of either a "zone call" button or "all-zone call" button , chime tone shall sound & silently mute any lower priority signal which is broadcasted through the selected zone(s) and upon completion of the chime sound, the microphone shall be switched ON and a MIC LIVE lamp shall light indicating that the operator can call or page. Upon completion of the announcement, the operator shall press a button which will automatically fade into the normal input (background music source/lower priority signal).

2.14 AUDIO IP DECODER

- A. Refer to the technical specification mentioned in clause 2.3.6 above.

2.15 AUDIO DISTRIBUTION AMPLIFIER

- A. The audio distribution amplifier shall distribute 1 input to 6 outputs.
- B. The audio distribution amplifier shall have at least the following specifications:
- No. of inputs x No. of outputs : 1 x 6
 - Input signal level : 0 dB m , 10 K ohms (electronically balanced)
 - Output single level : 0 dBm , 600 ohms (electronically balanced)
 - Frequency response : 20 Hz to 20 kHz (+ 0 / - 1 dB)
 - THD : < 0.03 %

2.16 POWER AMPLIFIER

- A. The power amplifier shall be of 19 inch rack mount.
- B. No more than 2 amplifier output ratings should be provided (e.g. 120W and 240W) to facilitate interchangeability.
- C. The amplifier output shall be fully protected against mismatch, overload, short-circuit and eventual switching transients. An illuminated VU meter with ballistics corresponding to IEEE standards shall be mounted on the front panel. A level control, ON/OFF switch, pilot light and panel mounted fuse shall be fitted. Balanced or single-ended 50, 70 and 100 volt outputs shall be available at convenient screw terminal strips.
- D. The amplifiers shall be fully protected against short and open circuits and shall include protection against thermal overload and eventual transients. Fuses (preferably front panel mounted) shall be clearly labeled with rating and type.
- E. Power "ON/OFF" indicators shall be fitted on the front panels.
- F. Gain controls shall be internal or lockable preset type, preferably with stepped attenuation in 2dB steps.

- G. Each amplifier shall be clearly labeled with the loudspeaker zone(s) served. (For parallel bank amplification, the labeling shall indicate the amplifier number).
- H. Initial design shall allow thirty percent (20%) spare capacity in each power amplifier.
- I. The power amplifiers shall be of compact single channel, rugged construction and shall have at least the following technical specification:
 - Power capacity : 120 W or 240 W RMS
 - Distortion : Less than 0.3 % at 1 kHz at rated output.
 - Frequency response : 40 – 18,000 Hz \pm 1dB.
 - Noise level : 80 dB below rated output.
 - Sensitivity : - 20 dBm to +4 dBm (0.775 V).
 - Input impedance : > 50 k ohm.

2.17 CEILING LOUDSPEKER

- A. The loudspeaker shall be of flush-mount ceiling type and shall be specially designed for background music and public address applications. These loudspeakers shall be installed in public areas & corridors as indicated on the drawings.
- B. The ceiling loudspeakers shall be high quality cone type and fitted with front metal grille and circular baffle plate for mounting in a suspended/concrete ceiling. A sample of the loudspeaker shall be submitted to the Engineer for approval.
- C. The ceiling loudspeakers shall be provided complete with 100V line matching transformer, with maximum insertion loss not greater than 0.5 dB over the frequency range 80 - 16000 Hz.
- D. The ceiling loudspeaker shall have at least the followings specification:
 - Power handling capacity : 6 Watt.
 - Rated Power output : 6 W RMS.
 - Power output selection : 6, 3 & 1.5 W RMS.
 - Input voltage : 100 V & 70 V.
 - Frequency response : 80 Hz-16000 Hz \pm 1dB.
 - Sensitivity : 90 dB / 1 W / 1m.
 - Minimum coverage angle : 90°@1kHz (6dB points on-axis level).

2.18 WALL LOUDSPEKER

- A. The wall loudspeakers shall be high quality cone type and fitted with front metal grille and splash proof housing. A sample of the loudspeaker shall be submitted to the Engineer for approval.
- B. The wall loudspeakers shall be fitted with steel mounting bracket for installation on wall which should be easily directed and provides a wide degree of movement so that it may be adjusted to face and cover any direction.
- C. The wall loudspeakers shall be provided complete with 100V line matching transformer, with maximum insertion loss not greater than 0.5 dB over the frequency range.
- D. The wall loudspeakers shall provide the following minimum performance:
 - i) Frequency response 50 Hz – 15 KHz \pm 3 dB
 - ii) Characteristic sensitivity level (SPL @ 1m on axis for 1W RMS input) > 96 dB
 - iii) Input voltage: 100 V
 - iv) Rated Power Input 12 watt RMS (with tapping at 3 ,6 & 12 watt)
 - v) Minimum coverage angle (included angle between -6dB points on -axis level 90° @ 1 KHz.

2.19 VOLUME CONTROL

- A. The volume control shall be achieved in seven steps 0,-3,-6,-9,-12,-18 dB and off.
- B. The rating of the volume control shall be as mentioned in bill of material or indicated on drawings.

2.20 SEPARATE SOUND SYSTEM FOR PRAYER ROOM AND CLASS ROOM

2.20.1 RACK CABINET

- A. A standard 19 inch rack or racks, as detailed in BS 5954, shall be provided to house the central equipment. Provide 20% spare space in each rack for future extension.
- B. The rack cabinet shall be equipped with power conditioner, power distribution unit, blower units and lockable plexi-glass door

2.20.2 COMPACT DISC PLAYER

- A. A rack mounted compact disc (CD) player shall be provided for intensive professional use with constant, day-long operation with the ability to Play MP3 Media

- B. The CD player shall provide the following minimum facilities:
 - i) CD with capacity of 5 discs.
 - ii) Continuous repeat of a pre-programmed track selection
 - iii) Latching pause control
 - iv) Visible display of track number and of total playing time on the inserted disc.
- C. The CD player shall include a cartridge for pre-loading of 5 compact discs, with random track selection facilities.
- D. The CD player shall provide the following minimum performance:
 - i) Frequency response 20Hz - 20 KHz \pm 0.5dB
 - ii) Signal-to-noise (S/N) ratio > 100dB(A)
 - iii) Channel separation > 85dB
 - iv) Harmonic distortion < 0.01% @ 1 KHz.

2.20.3 AUDIO MIXER POWER AMPLIFIER

- A. The audio mixer power amplifier shall be microprocessor based control type, capable of having four microphone inputs and six line inputs with utmost simplicity in operation and modular construction.
- B. The audio mixer power amplifier shall be interface with fire alarm system to mute the sound level in case of fire alarm reporting.
- C. The master section shall include an electronically balanced main output, a rotary level control, a signal present indicator, adjustable treble and bass equalization and a limiter with adjustable threshold and indicator.
- D. The 100 V power amplifier output shall be fully protected against mismatch, overload, short-circuit and eventual switching transients. An illuminated VU meter with ballistics corresponding to IEEE standards shall be mounted on the front panel. A level control, ON/OFF switch, pilot light and panel mounted fuse shall be fitted. Balanced or single-ended 25,50,70 and 100 volt. Outputs shall be available at convenient screw terminal strips.
- E. The power amplifier shall be of rugged construction and shall at least the following specifications:

Power capacity	:	600 W
Distortion	:	Less than 0.1 % at 1 kHz at rated output.
Frequency response	:	20 - 20000 Hz (+ 0/-1 dB).
Noise level	:	< 80 dBu.
Sensitivity	:	-20 dB to + 4 dB

2.20.4 CEILING LOUDSPEAKER

- A. The loudspeaker shall be of flush-mount ceiling type and shall be specially designed for background music.
- B. The loudspeaker shall be complete with metal grille and fire dome.
- C. The ceiling loudspeaker shall have at least the following specification:-

Power handling capacity	:	6 Watt
Power output selection / tapping	:	6,3 & 1.5 W
Input voltage	:	100 V.
Frequency response	:	80 Hz-16000 Hz.
Sensitivity	:	90 dB / 1W/1m.

2.20.5 VOLUME CONTROL

- C. The volume control shall be achieved in seven steps 0,-3,-6,-9,-12,-18 dB and off.
- D. The rating of the volume control shall be as mentioned in bill of material or indicated on drawings.

2.20.6 DYNAMIC MICROPHONE

- A. The dynamic hand held microphone shall be rugged, unidirectional type and suitable for vocals/ musical instruments use.
- B. The microphone shall be equipped with On/Off switch.
- C. The unit shall have at least the following specifications:
 - Frequency response : 80 Hz to 18 kHz
 - Impedance : 250 ohm, balanced
 - Sensitivity : 1.5 Mv (-56 dB)

2.20.7 FLOOR STAND

- A. Folding floor-stand black & chrome color with height 1 to 1.6 m with adjustable boom arms shall be provided.
- B. The stand shall be provided complete with 3/8 inch thread for microphone support as well as clip for microphone.

2.20.8 TABLE STAND

- A. The table stand shall be black in color, complete with flexible gooseneck suitable for microphone connection.

2.20.9 WIRELESS MICROPHONE RECEIVER

- A. The unit shall be dual channel (equipped with two RF tuners) and use diversity technique to assure permanent receiving.

- B. The unit shall be equipped with ON/OFF LED, RF level indicator and squelch control on the front panel.
- C. An adequate number of antennas shall be supplied and installed in the room to ensure proper coverage for the wireless microphone pick-up devices.

The unit shall operate within UHF range (450 to 960 MHz).

- D. The unit shall have 32 presets (programmable frequencies) that can freely selected in 5 KHz steps.

2.20.10 HAND HELD WIRELESS MICROPHONE

- A. The hand held wireless microphone shall be unidirectional type, suitable for voice and music applications with frequency synthesis and high acoustical performance.
- B. The microphone shall be equipped with semi rigid removable antenna, On / Off switch and battery capacity indicator.
- C. The hand held wireless microphone shall have at least the following specifications:

Frequency response	:	50 Hz to 20,000 Hz
Signal to noise ratio	:	115 dB(A)
THD (at 1 kHz)	:	0.3 %

2.20.11 TIE-CLIP WIRELESS MICROPHONE

- A. The Tie-clip wireless microphone shall be omnidirectional type, suitable for speech, with frequency synthesis and high acoustical performance.
- B. The microphone shall be equipped with semi rigid removable antenna, On / Off switch and battery capacity indicator.
- C. The Tie-clip wireless microphone shall have at least the following specifications:

Frequency response	:	60 Hz to 18000 Hz
Signal to noise ratio	:	> 112 dB(A)
THD	:	< 0.5 %

- D. The system shall be interfaced with Fire Alarm System to mute the sound system loudspeakers in case of fire alarm reporting.

2.21 SEPARATE SOUND SYSTEM FOR AUDITORIUM

2.21.1 RACK CABINET

- C. A standard 19 inch rack or racks, as detailed in BS 5954, shall be provided to house the central equipment. Provide 20% spare space in each rack for future extension.
- D. The rack cabinet shall be equipped with power conditioner, power distribution unit, blower units and lockable plexi-glass door

2.21.2 COMPACT DISC PLAYER

- A. A rack mounted compact disc (CD) player shall be provided for intensive professional use with constant, day-long operation with the ability to Play MP3 Media
- B. The CD player shall provide the following minimum facilities:
 - i) CD with capacity of 5 discs.
 - ii) Continuous repeat of a pre-programmed track selection
 - iii) Latching pause control
 - iv) Visible display of track number and of total playing time on the inserted disc.
- C. The CD player shall include a cartridge for pre-loading of 5 compact discs, with random track selection facilities.
- D. The CD player shall provide the following minimum performance:
 - i) Frequency response 20Hz - 20 KHz \pm 0.5dB
 - ii) Signal-to-noise (S/N) ratio > 100dB(A)
 - iii) Channel separation > 85dB
 - iv) Harmonic distortion < 0.01% @ 1 KHz.

2.21.3 AUDIO SWITCHING MATRIX

- A. A microprocessor controlled, modular audio switching matrix shall be provided to assign any audio input source to a designated any audio outputs, with the required priorities between inputs.
- B. The main function required by matrix is to achieve a room combining for the four partitions of the ball room so that the sound reinforcement system may be divided into two, three or four rooms/ partition with full control and operation facilities for each partition.
- C. The audio switching matrix shall have at least 8 audio inputs for sound sources and 8 audio outputs to feed the loudspeakers in the ball room partitions as indicated on drawings.
- D. The audio switching matrix shall have at least 8 control inputs and 8 control outputs (free voltage dry closures).
- E. The audio switching matrix shall be of a modular construction and can be extended up to 12 audio inputs and 12 audio outputs.

- F. The audio switching matrix shall be provided with the software with facility of easy programming / reprogramming and operation of the all matrix functions (e.g. programmed priorities, fade-in, fade out, combining facility, ...etc). All commands of programming and operation shall be displayed on LCD.
- G. The audio switching matrix shall have automatic self diagnostic function which shall be appeared on the LCD display.
- H. The audio switching matrix shall be interfaced with the integrated presentation system to permit remote controlling of all matrix functions and operation (e.g. volume controlling, room combining, ...etc) via the touch panels of the integrated presentation system.
- I. The audio switching matrix shall have the ability to be connected to a host computer via RS-232 interface.
- J. The audio switching matrix shall be interfaced with fire alarm system to mute the sound level in case of fire alarm condition.
- K. The audio switching matrix shall have at least the following minimum performance:
 - Frequency response : 20-20000 Hz (± 0.5 dB)
 - Distortion : Less than 0.1 %
 - noise level : 85 dB below rated output
 - Output level : 0Bm line level (0.775 V), max. 14 dBm
 - Output impedance : < 600 ohm
 - PC interface : RS 232

2.21.4 AUDIO DISTRIBUTION PREAMPLIFIER

- A. The audio distribution preamplifier shall distribute 1 input to 8 outputs or could be configured as two independent 1 x 4 distribution preamplifier.
- B. The audio distribution preamplifier shall have at least the following specifications:
 - No. of inputs x No. of outputs : 1 x 8 or 2 x 1 x 4
 - Input single level : 0 dBu , 10 K ohms
(electronically balanced)
 - Output single level : 0 dBu , 600 ohms
(electronically balanced)

- Frequency response : 20 Hz to 20 kHz (+ 0 / - 1 dB)
- THD : < 0.03 %

2.21.5 DUAL CHANNEL GRAPHIC EQUALIZER

- A. The graphic equalizer shall be dual channel 1/3 octave, 30 bands centered at ISO standard frequencies.
- B. The equalizer shall be " Fail - safe ", i.e the signal path shall automatically bypass the equalizer in the event of failure of power supply to the unit.
- C. The graphic equalizer shall have at least the following specifications:
 - Frequency response : 20 Hz to 20 kHz (+ 0 / - 0.5, dB)
 - Total harmonic distortion : < 0.01 %
 - Hum and noise : < -88 dB

2.21.6 DUAL CHANNEL FEEDBACK ELIMINATOR

- A. The feedback suppressor / eliminator unit shall be dual channel equipped with 6 fixed FBX filters and 3 dynamic filters in the range of 51 Hz to 17 kHz.
- B. Filter depth shall be from 0 dB to -40 dB with a switchable width in 1/5 or 1/10 octave. The unit shall be fitted with a peak limiter threshold variable from -10 dB to + 10 dB.
- C. The unit shall be equipped with an active/bypass switch for feedback suppressor, limiter and output level controls.
- D. The feedback eliminator shall have at least the following specifications:
 - Frequency response : 20 Hz to 20 kHz (+ 0 / - 0.5, dB)
 - Signal to noise ratio : 86 Db
 - Distortion : < 0.004 %

2.21.7 DUAL CHANNEL COMPRESSOR / LIMITER

- A. The compressor / limiter unit shall have at least the following specifications:
 - Frequency response : 20 Hz to 20 kHz (\pm 1 dB)
 - Distortion : < 0.1 %

- Noise level : -92 dBm
- Leveler threshold : -40 dBm to 0 dBm
- Noise Gate : -80 dBm to - 40 dBm

2.21.8 DUAL CHANNEL POWER AMPLIFIER

- A. The power amplifier shall be dual channel and provide 325 watt into an 8 ohm load per channel or 950 watt of power into 8 ohms load in mono bridged mode.
- B. The power amplifier shall have a complete short circuit and thermal protection with automatic reset.
- C. The power amplifier shall be equipped with 2 – speed fan cooled.
- D. The power amplifier shall have at least the following specifications:
 - Frequency response : 20 Hz to 20 kHz (+0/- 1 dB)
 - Total harmonic distortion : < 0.1 % at rated power
 - Signal to noise ratio : > 100 dB
 - CMRR : > 80 dB
 - Gain : 33 dB

2.21.9 MAIN WALL LOUDSPEAKER

- A. The main loudspeaker shall be two – way system comprises 12 inch cone speaker and CD horn (90° x 40°).
- B. The loudspeaker shall contain passive X-over set at 3.2 kHz.
- C. The loudspeaker shall be complete with wall mounting brackets.
- D. The loudspeaker shall have at least the following specifications:
 - Power rating : 360 W continous program
 - SPL : 97 dB/ 1W / 1m
 - Frequency response : 60 Hz - 20 kHz (\pm 3 dB)
 - Impedance : 8 ohm
- E. Associated equipment for loudspeakers:

1. All loudspeakers shall be phased together.
2. Each portable loudspeaker shall have two male connectors, wired in parallel, mounted in the rear.
3. Portable loudspeaker cables shall be standard loudspeaker cables, 8m long. They shall consist of jacketed # 12 AWG conductors with phasing code.
4. Receptacles for portable loudspeakers shall be mounted at the locations and in the quantities shown on the drawings.
5. Layout and mounting arrangements of loudspeakers shall be as required to provide specified coverage of the seating area.
6. Loudspeakers shall be easily removable and replaceable in the same position and shall have safety cable attachment to framework or proper structure support.
7. There shall be resilient mounting between the loudspeaker and support structure in the form of double deflection neoprene hangers. Isolators shall provide a minimum of 90 % isolation at 35 Hz.
8. Design of the suspension arrangement, exact mounting details and aiming shall be indicated on the shop drawing submitted to the consultant for review prior to installation.

2.21.10 REMOTE CONTROLLED VOLUME CONTROL

- A. This unit shall control the audio signal level (line level) locally from the control room or remotely via the touch panel of the integrated presentation / control system.
- B. The unit shall have at least the following specifications:
 - Frequency response : 20 Hz to 20 kHz (+ 0 /-0.5 dB)
 - Total harmonic distortion : < 0.01 %
 - Signal to noise ratio : < - 88 dB

2.21.11 DYNAMIC MICROPHONE

- D. The dynamic hand held microphone shall be rugged, unidirectional type and suitable for vocals/ musical instruments use.
- E. The microphone shall be equipped with On/Off switch.
- F. The unit shall have at least the following specifications:
 - Frequency response : 80 Hz to 18 kHz

- Impedance : 250 ohm, balanced
- Sensitivity : 1.5 Mv (-56 dB)

2.21.12 FLOOR STAND

- C. Folding floor-stand black & chrome color with height 1 to 1.6 m with adjustable boom arms shall be provided.
- D. The stand shall be provided complete with 3/8 inch thread for microphone support as well as clip for microphone.

2.21.13 TABLE STAND

- E. The table stand shall be black in color, complete with flexible gooseneck suitable for microphone connection.

2.21.14 WIRELESS MICROPHONE RECEIVER

- E. The unit shall be dual channel (equipped with two RF tuners) and use diversity technique to assure permanent receiving.
- F. The unit shall be equipped with ON/OFF LED, RF level indicator and squelch control on the front panel.
- G. An adequate number of antennas shall be supplied and installed in the room to ensure proper coverage for the wireless microphone pick-up devices.

The unit shall operate within UHF range (450 to 960 MHz).

- H. The unit shall have 32 presets (programmable frequencies) that can freely selected in 5 KHz steps.

2.21.15 HAND HELD WIRELESS MICROPHONE

- D. The hand held wireless microphone shall be unidirectional type, suitable for voice and music applications with frequency synthesis and high acoustical performance.
- E. The microphone shall be equipped with semi rigid removable antenna, On / Off switch and battery capacity indicator.
- F. The hand held wireless microphone shall have at least the following specifications:

Frequency response	:	50 Hz to 20,000 Hz
Signal to noise ratio	:	115 dB(A)
THD (at 1 kHz)	:	0.3 %

2.21.16 TIE-CLIP WIRELESS MICROPHONE

- A. The Tie-clip wireless microphone shall be omnidirectional type, suitable for speech, with frequency synthesis and high acoustical performance.

- F. The microphone shall be equipped with semi rigid removable antenna, On / Off switch and battery capacity indicator.
- G. The Tie-clip wireless microphone shall have at least the following specifications:

Frequency response	:	60 Hz to 18000 Hz
Signal to noise ratio	:	> 112 dB(A)
THD	:	< 0.5 %
- H. The system shall be interfaced with Fire Alarm System to mute the sound system loudspeakers in case of fire alarm reporting.

2.22 ENVIRONMENTAL CONDITIONS

- A. External loudspeakers shall be weatherproof, with ingress protection meeting at least IP54 in accordance with BS EN 60529 (IEC 529).
- B. As far as is practicable, all loudspeakers shall be fire resistant, either by inherent construction or by fire-resistant enclosure.
- C. The design and installation shall provide the maximum practicable protection of the loudspeaker line during a fire. All loudspeaker enclosures shall be fitted with twin threaded inserts to accommodate 20mm glands for direct entry and exit of mineral-insulated copper sheathed cables complying with BS 6207. Any loudspeaker types for which this requirement cannot be met shall be clearly identified within the Tender.
- D. The colors and finishes of all loudspeakers shall be approved by the consultant.

2.23 LOUDSPEAKER INTERCONNECTIONS

- A. All loudspeakers shall be supplied with high quality audio transformers. The transformers shall have a minimum of 3 secondary tapings, with a ratio of at least 4:1 between the highest and the lowest tapings (6dB power factor). tapings shall be clearly labeled with the wattages.
- B. Any revision of the loudspeaker layout shall be subject to approval by the consultant.

2.24 SYSTEM WIRING

A. RESPONSIBILITIES

1. The contractor shall be responsible for the supply and installation of all input and outlet panels and for all terminations.
2. All cables and back boxes shall be supplied by and installed by the contractor. The contractor shall take complete responsibility for

compliance with BS 5839, BS 6259, IEE regulations and local by-laws, and for the operation and performance of the system, including wiring.

B. CABLES

1. All wiring shall be copper sheathed, PVC insulated audio cable with a low smoke fume and oversheath, colored red to BS 6207.
2. All cables shall have a unique reference number, and shall be clearly and permanently labeled at each end.
3. Loudspeaker cables shall be sized to ensure not more than 0.5dB power loss, assuming an additional future power load of at least +10% on each circuit.
4. Wiring shall be performed by means of twisted pairs of such cross-section that have the resistance at the worst point is not more than 5 per cent of the nominal amplifier output impedance.
5. All system wiring shall be installed in the existing cable trunking or in conduits.

C. CONNECTIONS AND TERMINATIONS

In-line connections shall be limited to the absolute minimum practicable. Any such joints shall be within suitable steel junction boxes.

Connection to equipment racks shall be via marshalling boxes, The boxes shall be fitted with fixed terminal strips, which shall be permanently annotated with unique circuit reference numbers.

Final connections between the marshalling boxes and the racks shall be via suitable flexible cables of sufficient length to gain working access to the rear of the racks.

Internal rack connections shall be either hard-wired or via professional type audio connectors, preferably of the latching type.

2.25 ELECTROMAGNETIC INTERFERENCE

- A. All equipment supplied shall be immune from and shall not radiate signals exceeding the limits of BS 800 and BS 6667.
- B. Protection shall be provided by means of surge suppressers to any equipment including cables which may be vulnerable to voltage transients, in a manner approved by the Owner's Authorized Representative. This shall include the incoming mains connection to the power supply unit. The equipment manufacturers instructions shall be observed in applying the protection.
- C. Cables shall be segregated from all other cables by at least 300mm in any direction as far as practical. Cables shall only cross at right angles.

- D. The installation of equipment shall be fully coordinated with the building fabrics and finishes, in a manner approved by the consultant.
- E. The method of fixing and the mounting height of flush and surface mounted equipment shall be approved by the consultant.
- F. The method of connecting incoming and outgoing cables shall be approved by the Owner's Authorized Representative.
- G. All equipment shall be fixed true and level to the surfaces on which it is mounted with a tolerance of +/- 0.5mm.

PART 3: EXECUTION

3.1 INSTALLATION

- A. The contractor shall supply all equipment, pre-wired equipment racks, receptacle plates, consoles, mounting hardware and accessories etc, required for complete and functioning systems.
- B. Rack mounted equipment, switches, jacks, outlets, etc., shall be permanently identified with either engraved lamaroid labels. Submit samples of proposed labels for approval.
- C. Care shall be exercised in wiring, so as to avoid damage to the cables and to the equipment. Between racks, cabinets, consoles or modules, all cables shall be well-supported and shall be neatly laced and dressed. All joints and connections shall be made with rosin-core solder or with mechanical connectors.
- D. Between racks, cabinets, consoles or modules, all cable shall terminate in punch-blocks.
- E. All power and a high level circuit shall be run on the right side of the rack or cabinet as viewed from the rear. All other circuit shall be run on the left side as viewed from the rear.

3.2 WARRANTY

- A. Provide the services that shall be provided by the system engineer to assist the personnel assigned by the Employer during the installation and commissioning period.
- B. Five (5) sets of instruction manuals shall be provided for the sound system. All manuals shall be in the English language.
- C. Obtain from the manufacturer of the equipment a warranty that all equipment supplied will be free of defects in labour, materials and workmanship and will perform satisfactorily in compliance with all pertinent specification for a period of two (2) year after commissioning.

3.3. WORKS INSPECTION

- A. The contractor shall arrange for works inspection of the central equipment racks and IT rooms racks. The contractor shall advise the consultant when the equipment has been fully works tested and is ready for pre-delivery inspection. Temporary

circuits shall be connected, as necessary, to enable complete testing of all audio paths, zoning, priority switching.

3.4 PERFORMANCE TESTS

- A. After compiling with the procedures set out in the preliminaries, the contractor shall carry out full tests on the contract works to demonstrate that the works meet the requirements of the contract documents.
- B. The contractor shall allow a minimum of 3 days (7 hours per day) for demonstration of the equipment and attendance, plus:
 - i) 4 days for instruction of operational staff.
 - ii) 2 days for system tuning and adjustment if found to be necessary.
- C. The contractor shall arrange for all or part of the above work to be carried out outside normal working hours as may be required and shall include for all costs in so doing.
- D. The contractor shall have available at commissioning the following electro-acoustic test equipment:
 - 1. TEF 20 (Time, Energy and Frequency) Analyzer.
 - 2. Calibrated sound level meter, complying with BS 5969 (IEC 651) Type 1 or 2
 - 3. 1/3 octave band spectrum analyses (minimum range 40HZ - 16 KHz at ISO center frequencies, display resolution increment not more than 2dB)
 - 4. Pink Noise Source (minimum bandwidth 20Hz - 20 KHz, 0.5 dB)
 - 5. Oscilloscope for wave-form analysis
 - 6. Loudspeaker's phase checker
 - 7. Impedance meter for checking the impedance of the loudspeakers' lines.
 - 8. Portable wireless intercom approved for use on site
 - 9. Amplifier for use with item (3) above, and sufficient loudspeakers to produce overall sound pressure level that is more than the noise level by 10dB for each area containing an ambient noise sensing transducer. The noise level shall be uniform throughout the area to 2dB of the mean, measured 1.5m above the floor.
- E. If required by the consultant (in the event of apparent non-compliance of the installed system with the specification), the contractor shall provide precision test equipment for verification of Voltage, Power, Frequency Response, Single-to-Noise Ratio, Total Harmonic Distortion and RASTI.

3.5 PERSONNEL TRAINING

- A. Building Operating Personnel Training: Train Owner's building personnel in procedures for starting up, testing and operating sound system and auxiliary equipment. Furnish three operator's manual providing installation and operating instructions

END OF SECTION 28

SECTION 29

TESTING AND COMMISSIONING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and special Conditions (General requirements), apply to work of this section.
- B. Basic electrical materials and methods, section 16050 applies to work of this section.

1.2 DESCRIPTION OF WORK

- A. The work covered by this section consists of providing all tools, labour, equipment, and materials, and performing all operations in connection with the final acceptance testing of electrical installations prior to handing over and testing of existing installations as required for diagnosing faults and preparation for repair or renewal.
- B. (Commissioning testing is the responsibility of the contractor who must satisfy himself that all equipment is installed properly and in good working order before final acceptance tests are carried out in the presence of the engineer.)

1.3 REFERENCES

A. APPLICABLE STANDARDS

When a new Egyptian is issued it automatically takes precedence over any other standard or specification mentioned below.

B. INTERNATIONAL STANDARDS

International Standard Organization (ISO)

ISO 8528	Reciprocating internal combustion engine driven alternating current generating sets
ISO 8528-6:93 Part 6:	Test Methods.
ISO 8528-8:96 Part8: Sets.	Requirements and Tests for Low Power Generating
ISO 8528-9:96 Part 9 Vibrations.	Measurement and Evaluation of Mechanical
ISO 8528-10:99 Part 10:	Measurement of Airborne Noise by the Enveloping Surface Method.
ISO 8528-12:98 Part 12:	Emergency Power Supply to Safety Devices.

C. INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60076-3: 80	Part 3: Insulation Levels and Dielectric Tests
IEC 60439	Low Voltage Switchgear and Control Gear Assemblies,
IEC 60439-1:92(96)	Part 1: Type Tested and Partially Type Tested Assemblies.
IEC 60502-1: 97	Part 1: Cables For Rated Voltages Of 1 kV .
IEC 60947	Low Voltage Switchgear And Control Gear.
IEC 61117 : 92 A	Method for Assessing the Short-Circuit Withstand Strength of Partially Type-Tested Assemblies.
IEC 61180	High Voltage Test Techniques for Low Voltage Equipment.
IEC 61180-1: 92(94)	Part 1: Definitions Test and Procedure Requirements.
IEC 61180-2: 94	Part 2: Test Equipment.
IEC 61557	Electrical Safety In Low Voltage Distribution Systems up to 1000 V A.C. and 1500 V DC; Equipment For Testing, Measuring or Monitoring of Protective Measures.
IEC 61557-1: 97	Part 1: General Requirements.
IEC 61557-2: 97	Part 2: Insulation Resistance.
IEC 61557-3: 97	Part 3: Loop Impedance First Edition.
IEC 61557-4: 97	Part 4: Resistance Of Earth Connection And Equipotential Bonding.
IEC 61557-5: 97	Part 5: Resistance To Earth
IEC 61557-6: 97	Part 6: Residual Current Devices In TNS Systems.

PART 2 - PRODUCTS

2.1 WORKS TESTS

- A. The Engineer shall inspect and test at the makers' works, during manufacture and after completion, all or any particular manufactured material, apparatus or equipment ordered by the contractor for incorporation in the works, in order to prove that the material, apparatus or equipment meets the requirements of this specification. The contractor shall notify the Engineer in advance of all such inspections and tests.
- B. The Engineer must arrange on his expenses for works tests to be attended by the Engineer for all tests specified in different sections of specifications.
- C. The Contractor shall submit to the Engineer, at the time of issue, three copies of each and every order for bought in material, apparatus and equipment intended for incorporation in the works.

Each such order shall clearly state whether the item(s) which it covers is or are subject to inspection or test before despatch to site.

- D. Upon completion of manufacture, or before despatch in the case of stock items, all material, apparatus and equipment intended for incorporation in the works shall be subjected, to the tests specified in the relevant National Standard or elsewhere in this specification together with such additional tests as may be required in order to prove compliance with this specification. When no relevant British Standard exists, or the appropriate National Standard fails to specify tests, the Contractor shall submit his proposals for the tests he requires to provide compliance with the specification.
- E. The results of each and every test carried out in accordance with the provisions of this specification shall be accurately and comprehensively recorded on a form of test certificate signed by the person in charge of the testing procedure and countersigned by the contractor and four copies of every such test certificate shall be submitted to the Engineer.
- F. Every test certificate shall include, in addition to all other requirements the date and time of the test, the ambient conditions, a fully detailed description of the test(s) carried out, the results obtained, and any relevant performance curves.
- G. The Contractor shall be responsible for ensuring that the Engineer is advised in writing whenever material, apparatus or equipment is ready for inspection or test at his own or his suppliers' premises. At least seven days notice shall be given, and due allowance shall be made for this period of notice in drawing up the program of works.
- H. In cases where the manufacturer or supplier of material, apparatus or equipment relies upon type tests to prove, either wholly or in part, the suitability of his product(s), then the Contractor shall arrange for triplicate copies of certificates giving the results of such type tests to be submitted to the Engineer at the time the order is placed.
- I. No material, apparatus or equipment, from whatever source, shall be despatched to site until the Engineer has had the opportunity to inspect it or has given written authorization for despatch.
- J. No inspection or testing by the Engineer nor the witnessing of satisfactory tests nor the authorizing of despatch to site shall in any way relieve the contractor of any of his obligations under this contract, nor shall it in any way limit the right of the Engineer to reject such items after delivery to site if they subsequently prove to be defective or unsatisfactory or unsuitable for their intended purpose.
- K. When the contractor has ordered equipment from a manufacturer who, in turn, has bought-in major components from a secondary supplier, the Engineer shall have the right to elect to inspect such components at the works of the secondary supplier, and the contractor shall ensure, when placing his orders, that such rights are secured.

For the purposed of this clause, inter-departmental orders within the same organization shall be treated in the same manner as orders involving separate organizations.

- L. The Engineer shall have the right to waive, at his sole discretion, the requirements relating to his inspection of materials, apparatus, and equipment at the makers' works. The exercise by the Engineer of this right shall not in any way relieve the

contractor of his obligation to carry out the prescribed tests and to submit test certificates.

- M. No work shall be painted or otherwise prepared for despatch until it has been inspected by the Engineer, or inspection has been waived and despatch has been authorized.
- N. When one or more of the Contractor's purchase orders covers the supply of a number of like components or items of equipment, the Engineer shall have the right to select that one item or component of each type and rating be subjected to type tests as described in the relevant National Standard. Other similar items may then be subjected only to routine tests.

2.2 SITE TESTS

- A. The Contractor shall carry out all necessary checks and tests to prove that the completed installations fully comply with specified requirements.
- B. Upon completion of the electrical installation, or any substantial section thereof, the installation, or any substantial section thereof, the installation or that section and all of the associated electrical equipment shall be subjected to the tests specified in the relevant National Standards and in the IEE Wiring Regulations, together with such other tests as may be specified in order to prove compliance with the Specification.
- C. All of the required checks and tests shall be carried out in accordance with a program to be agreed with the Engineer, and facilities shall be made available for the Engineer to be present at all such checks and tests if he so desires.
- D. Tests not carried out in the presence of the Engineer shall not be regarded as valid for the purpose of the Contract, unless the Owner's Authorized Representative shall not be regarded as valid for the purpose of the Contract, unless the Engineer shall have authorized the Contractor to proceed with the testing process in his absence.
- E. Every test certificate shall include, in addition to all other requirements, the date and time of the test, the ambient conditions, a fully detailed description of the test (s) carried out, the result obtained, and any relevant performance curves.
- F. No material, apparatus, equipment, or installation shall be covered or otherwise permanently concealed from view until the Engineer has had the opportunity to inspect it, or given written authorization for covering to proceed.
- G. No work shall have a final paint finish until it has been inspected by the Engineer or painting has been authorized, unless the final paint finish is necessary to provide the necessary climatic protection.
- H. No apparatus, equipment, plant, or installations will be recognized as complete until all of the specified inspections and tests have been satisfactorily carried out.
- I. The Engineer shall have the right to waive, at his sole discretion, the requirements relating to his inspection of materials, apparatus equipment and installations and the witnessing of tests thereon. The exercise by the Owner's Authorized Representative of this right shall not in any way relieve the Contractor of his obligations to carry out the prescribed tests and to submit test certificates.

2.3 TEST INSTRUMENTS

A. MULTI-METERS

Multi-meters shall be professional quality, with electronic measuring circuits fully protected against overvoltage, digital readout and true R.M.S. indication. They shall be equipped with sufficient scales to enable any reading to be at least 60% of maximum scale reading, and accuracy shall be not less than $\pm 5\%$ of full scale.

B. INSULATION TESTERS

Insulation testers shall conform to IEC 61557-2.

C. CABLE FAULT LOCATION SETS

Cable fault location test sets shall measure distance to fault by measuring time of reflection of test impulse voltage or other method of comparable accuracy.

D. EARTH CONTINUITY TESTERS

Earth continuity shall be measured according to IEC 61557-3 and IEC 61557-4 by injecting current (generally 25 amperes) into the circuit to be tested and measuring voltage drop at accessible points. The use of relatively high current is required to locate loose or poor connections that would fail during an earth fault but might not be detected during a low current test such as using an ohmmeter.

E. EARTHING ELECTRODE OR SYSTEM RESISTANCE TEST SET

Equipment for measuring Earth Electrode resistance shall conform to Egyptian code with two test earth electrodes and injecting a current between earth electrode and a test electrode at a distance from the main earth. A potential electrode is then inserted and volt drop measured between the ground and the main earth electrode from which the earth resistance can be measured.

F. TESTING RESIDUAL CURRENT DEVICES

Equipment for testing Residual Current devices shall conform to IEC 61557-6.

G. LUX METER

Utilising a photoelectric cell to measure incident light. The meter shall have a calibrating light circuit and shall have an accuracy of at least $\pm 5\%$

2.4 TESTS

A. LOW-VOLTAGE CABLES AND WIRES

The connection between the neutral and the earth busbar of LV switchboards and panelboards shall be removed, if any, and all motors and other loads shall be disconnected, except lighting fixtures, which shall be connected during the test, but with lamps removed.

The test voltage shall be applied between all normally live conductors (L1-L2, L1-L3, L2-L3), between normally live conductors and the neutral conductor (L1-N, L2-N, L3-N), between normally live conductors and protective conductor (L1-PE, L2-PE, L3-PE), and between neutral conductor and protective conductor (N-PE).

The test is satisfactory if the insulation resistance is equal or greater than 1000 Ohm per Volt operating voltage. E.g. for a 220/127 V system:

Between phases	220.000 Ohm.
Between phases and neutral or earth	127.000 Ohm.
Between neutral and earth	127.000 Ohm.

For a 380/220 V system:

Between phases	380.000 Ohm.
Between phases and neutral or earth	220.000 Ohm.
Between neutral and earth	220.000 Ohm.

An insulation test shall be performed on direct buried cables before and after backfilling of trenches and before the installation is put into service.

B. LOW-VOLTAGE SWITCHBOARDS, DISTRIBUTION BOARDS AND PANELBOARDS

Low-voltage switchboards, distribution boards and panelboards shall be type-tested and routine-tested according to IEC 60439-1, IEC 60890, IEC 60947-1, IEC 61117 and IEC 61180-1 in the factory. Only type-tested and partially type-tested LV switchboards and panelboards shall be accepted for building installations.

Before handing-over the insulation resistance between phases, phases and neutral, phases and earth and neutral and earth shall be measured and recorded.

Functional tests of all switching devices and protection relays, including manual and motor operation of switchgear, shall be performed.

The phasing sequence and phase colours/numbers, switchgear labelling, earthing and bonding shall be checked.

Control voltage for switchgear and protection relays shall be measured.

Cable terminations and connections, setting and correct tripping of protection and time relays, contactors and alarms, push-button stations, rating of fuse links, phase balance, correct indication of measuring devices shall be checked.

C. LIGHTING

Lighting fixtures shall be identified by a safety mark showing the internal protection (IP) of the luminaries. The mark is shown in the type plate of the luminary. A type test in an approved test institute shall establish the protection requirements of an IP class.

After installation of the lighting fixture on site, the following shall be checked:

- Operation of lighting fixture, fitted with lamps of correct wattage, type and colour.
- Circuit numbering, fuse or circuit breaker rating in distribution panels.
- Luminary earthing.
- Light switches.

Lighting levels shall be checked and recorded for all internal areas. Tests shall be carried out with all external lighting excluded. Maximum, minimum and average illumination levels shall be measured for all rooms. Measured values shall be multiplied by 0.7, to allow for depreciation in light output due to age and soiling. (This factor may be increased to 0.8 if it can be shown that the lamps have been burning for at least 100 hours prior to the test) Any illumination levels more than 10 % below those recommended by the Illuminating Engineering Society shall be brought to the attention of the engineer.

D. SWITCHES AND SOCKETS

Beside the insulation resistance test of lighting and socket circuits described above, light switches shall be checked for proper function.

The correct connection and functioning of the protective earthing conductors of sockets and the tripping of residual-current operated protective devices (fault-current circuit breakers) of socket circuits in the distribution panel shall be checked by means of socket testers.

Furthermore the number of socket-outlets per socket circuit shall be counted and listed.

E. POTENTIAL EQUALISATION AND EARTHING

Potential equalisation and earthing in buildings shall be realised and tested according to IEC 60364-5-54.

The test shall be performed at the main earth busbar of the building, with the earthing connections to the earth electrodes or earthing grid disconnected from the main earth bar.

The connections of transformer neutrals and transformer rails and switchgear enclosures to earth shall be inspected for tightness.

The continuity and conductivity of all protective, equipotential and earth-bonding conductors in the building, including socket-earthing contacts shall be measured and recorded.

The earthing of all exposed and extraneous metallic parts in the building, clearance distances in bathrooms, and proper marking of protective conductor connections in transformer, switchgear and generator rooms and in distribution panels shall be checked.

F. BUILDING CONTROL SYSTEMS

Control systems in buildings shall be tested according to the manufacturer's instructions and functional tests shall be performed according to recommendations given by relevant IEC standards for the particular system.

Failures shall be simulated and alarm indications recorded.

G. COMMUNICATION SYSTEMS

Communication systems in buildings shall be tested according to the manufacturer's instructions.

Functional tests shall be performed, failure and alarm conditions simulated and all data and alarm indications recorded.

All systems involving electronic private branch exchanges (EPABX) shall be tested on site and put in operation by the manufacturer's representative.

H. BATTERY SYSTEMS

1. LEAD ACID BATTERIES

A. UNSEALED CELLS

Unsealed cells shall be visually checked for electrolyte level and condition of plates. Connections shall be inspected and any chemical deposits removed, terminals cleaned and retightened using petroleum jelly for protection.

Electrolyte specific gravity shall be measured and compared with manufacturers recommendations.

Using load banks, disconnect from the input and measure discharge rate, and rate of reduction in terminal voltage. Total battery capacity shall be checked against supply specifications.

Immediately after discharge, reconnect supply and check battery charger current.
Measure rate of charge, time to full recharge and trickle current.

B. SEALED CELLS

Visually check for electrolyte level and condition of connections.
Perform the same tests as for unsealed cells (above)

I. UPS SYSTEMS

Test according to the Manufacturers instructions including the following:-
Simulated power failure.

Measure output current and rate of voltage drop, using dummy loads to simulate full design load current. Compare with manufacturer's data and design requirements.

Using a CRT, check voltage and current waveforms at no load, actual load and full design load.

PART 3 - COMMISSIONING

- A. Following the satisfactory conclusion of inspections and tests on completed sections of the Works, the Contractor shall duly commission each section of the electrical installation and leave it in full working order. The term 'Commissioning' shall be deemed to include:
- (i) The energizing of electrical distribution circuits and equipments which have previously been inspected, tested, found to be satisfactory and capable of being energize with complete safety.
 - (ii) The setting of electrical protective devices and systems, where relevant, in accordance with the directions of the Engineer or, failing such directions, in accordance with sound electrical engineering practice.
 - (iii) The starting up of all electrically powered plant and equipment.
 - (iv) The verification of the performance of all such plant and equipment by the carrying out, where required, of further tests and the making of all necessary adjustments so as to obtain optimum performance.
- B. Compliance with the requirements of this Section of the Specification shall not, by itself, in any way relieve the Contractor of any of his obligations under the Contract.
- C. The Contractor shall ensure that all connections and adjustments are made correctly, and that the installations and equipment are in a completely safe and satisfactory condition.
- D. All activities carried out by the Contractor in pursuance of the requirements of this section of the Specification shall be carried out, or continuously supervised, by a competent and experienced commissioning engineer.
- E. If considered necessary, the Engineer will set up a Commissioning Panel to oversee all activities relating to commissioning of installations, plant and equipment. The Contractor shall provide appropriate representatives as members of the Panel to act in an advisory capacity assisting the Engineer in all matters relating to the commissioning process.
- F. The Engineer shall have power to appoint an independent Commissioning Engineer to act on his behalf in the control of all activities relating to the commissioning process, and in such matters the said Commissioning Engineer shall be deemed to be an authorized representative of the Engineer.
- G. The Contractor shall be wholly responsible for ensuring that all switching operations and all work on electrical circuits and equipment which have once been energized are carried out in a thoroughly safe manner and shall operate, and rigidly adhere to, an approved 'permit-to-work' system. For this purpose, the Contractor shall appoint an 'authorized person' as defined in the Electricity (Factories Act) Special Regulations, and shall communicate the name of such person in writing to the Engineer.
- H. In appropriate cases the Contractor shall nominate a particular employee as 'Switchgear Operator' and shall ensure that all switchgear operations are carried out by the nominated person and that such person is always available for this duty when required.
- I. The Contractor shall prepare a commissioning schedule detailing the plant to be commissioned, the operations to be carried out, the time scale, with exact dates for specific operations, details of requirements for water and power services, and attendance or provisions by others. This commissioning schedule, in draft form, shall be submitted not less than four weeks in advance of the date on which commissioning is to commence.

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SPECIFICATIONS OF THE ELEVATOR

The contractor should read the Technical Specifications and obligations Carefully and Clearly. These documents shall be treated as essential parts of the Contract and Tenders.

1. A properly framed and enclosed legal hoistway, including adequate guards and protection of hoistway during the erection period.
2. Access to the machine room and machinery space as required by the governing code or authority.
3. Suitable machine room with legal access and ventilation, with concrete floor. Temperature in machine room to be maintained between 15°C and 32°C.
4. Suitable light and convenience outlets in machine room with light switches located within 450 mm of lock jamb side of machine room door.
5. A lockable fused disconnect switch or circuit breaker for each elevator per the Canadian Electric Code with feeder or branch wiring to controller(s) or starter.
6. A fused 120 Volts, A/C, 15 Amp. Single phase, power supply to each controller.
7. Venting of the hoistway as required by the governing code or authority.
8. Adequate supports for rail brackets, including spreader beams between multiple hoistway if required. Maximum bracket spacing as required by elevator contractor, but not to exceed 3050 mm.
9. Front entrance partition walls are not to be constructed until after door frame and sills are in place. If front walls are poured concrete bearing walls, rough openings are to be provided to accept entrance frame and filled in after frames are set.
10. Recesses, as required, to accommodate hall signal fixtures.
11. Dry pit reinforced to sustain normal vertical forces from rails and impact loads from buffers and cylinder head. Concrete cylinder head and buffer support not to be poured until cylinder is set in place.
12. Convenience outlet and light fixture in pit with switch located adjacent to the access door.
13. Where access to a pit over 1000 mm depth is by means of the lowest hoistway entrance, vertical iron ladder extending 1220 mm minimum above sill of access door.

14. Any cutting, patching, and painting of walls, floors, or partitions together with finish painting of entrance doors and frames.
15. Necessary electric power for light, tools, hoists, etc., during erection as well as electric current for starting, testing and adjusting the elevator.
16. A hoisting beam suitable for lifting a fully loaded elevator car.
17. Suitable means of access to and egress from location of cylinder well for truck mounted hole drilling rig.
18. Backfill around pit.
19. Provide sand and backfill cylinder.
20. Car inside dimensions: depends on the manufactured company (the subcontractor must be delivery three proposals for the car dimensions (elevator) before supplying the equipments).
21. Car material: mirror stainless steel or colored stainless steel.
22. Door operations: automatic operator for hoistway and car. Opening and closing speed to suit handicapped requirements.
23. Lighting the car hoistway.
24. Lighting: fluorescent type mounted above metal egg crate suspended ceiling with 13mm squares inside the car.
25. Ventilation single speed fans.
26. Emergency exit top exit in car top in accordance with code.
27. Car sills preferred made from extruded aluminum nickel silver.
28. Car operating station: buttons top row of buttons located maximum 1420mm from floor for accessibility by the handicapped. Other buttons emergency stop switch, alarm button door open button, door close button.
29. Emergency car lighting an emergency power unit employing a 6 volt sealed rechargeable battery and totally static circuits shall be provided that shall illuminate the elevator car and provide current to the alarm bell in the event of normal power failure. The equipment shall comply with the requirements of the common code.
30. Labels entrances shall be manufactured in accordance with procedures established by under-writers laboratories and shall be so labeled.
31. Sight guards shall be furnished on the leading edge of the doors to conceal the hoistway beyond the doors. Finish matching door panels.
32. Car floor indicator: one to be installed in each car as part of the car station.
33. Hall floor indicator: one for each elevator to be installed at main landing.

- 34. Car lantern and gong: a directional lantern visible from the corridor shall be provided in the car entrance.
- 35. Special emergency service: provide all requirements for special emergency service phase I and phase II plus fireman's service.
- 36. Emergency power: automatic standby building emergency power operation with manual override.
- 37. The machine shall be of the geared traction type in accordance with the applicable requirements of the Elevator codes. It shall have the motor, brake and traction drive sheave compactly mounted on a continuous steel bedplate and set on steel beams with sound isolation pads to reduce noise and vibration. The machine and motor shall be factory tested and aligned.
- 38. Machine location: overhead.
- 39. The motor shall have variable speed.
- 40. The machine brake shall be electrically released and spring applied and designed to give smooth stops under variable loads.
- 41. The ropes shall be constructed of traction steel and be of adequate size and number to give proper elevator operation and satisfactory wear
- 42. The elevator shall be protected from over speeding in the down direction with a centrifugal speed governor in the machine room and type a safety devices on the elevator car frame.
- 43. Rope brake: a Hollister Whitney rope gripper up direction over speed safety device shall be installed as required in the CAN/CSA B44-95 elevator safety code. Provide a detection system which will detect over speed in either direction and activate the rope gripper. Provide detection to protect against failures which result in slow speed movement away from the floor with the doors open and apply the rope gripper and stop the elevator within the distances required by the safety code.
- 44. The elevator shall be provided with an automatic leveling device which will bring the car to a stop within 6mm of the landing level regardless of load or direction of travel. Landing level will be maintained within the leveling zone irrespective of the hoistway doors being open or closed.
- 45. A microprocessor controller shall be provided. Including necessary starting switches of adequate size together with all relays, switches and hardware required to accomplish the operation specified. Overload protection shall be provided to protect the motor against overloading.

46. All wiring and electrical interconnections shall comply with the governing electricity codes. Insulated wiring shall have flame retardant and moisture proof outer covering, and shall be run in conduit, tubing or electrical wire ways. Traveling cables shall be flexible and suitably suspended to relieve strain on individual conductors.
47. Normal terminal stopping devices shall be provided. When an emergency terminal stopping device is also required, it shall be furnished and the controller switches and circuitry arranged in accordance with the requirements of the code.
48. A structural steel frame which carries steel plate counterweights shall be provided to properly balance the car.
49. The car platform shall have a fabricated frame of formed and structural steel shapes, rigidly welded. Sub-flooring shall be wood floor. The underside of the platform will be fireproofed.
50. A suitable car frame fabricated from formed or structural steel members shall be provided with adequate bracing to support the platform and car enclosure. The car frame shall be isolated from the platen plate by means of rubber isolation mounts. Shoe or slipper guides shall be mounted on top and bottom of the car frame to engage the guide rails. The crosshead shall be of sufficient strength to lift the fully loaded car when slung in the centre.
51. Steel elevator guide rails shall be furnished to guide the car, erected plumb and securely fastened to the building structure.
52. Sliding guides: guides shall be mounted on top and bottom of the car.
53. Roller guides: rubber roller guides shall be mounted on top and bottom of the car.
54. Doors on the car and at the hoistway entrances shall be power operated by means of a quality operator mounted on top of the car. The motor shall have positive control over the door movement for smooth operation. The car door shall have a safety shoe to cause instant re-opening should contact be made with any obstruction during the closing cycle.
55. Door operation shall be automatic at each landing with door opening being initiated as the car arrives at the landing and closing taking place after expiration of a time interval. A car door electric contact shall prevent starting the elevator away from the landing unless the car door is in its closed position.
56. An approved positive interlock shall be provided for each hoistway entrance which shall prevent operation of the hydraulic unit unless all doors for that elevator are closed

and shall maintain the doors in their closed position while the elevator is away from the landing. Provide emergency access to the hoistway as required by governing codes.

- 57.** The contractor shall install at each elevator landing served, a hoistway entrance of the type and size as previously described. Each entrance shall consist of flush hollow metal doors with build in hanger assembly, frames assembled for one piece unit installation, extruded aluminum sill, fascia, toe guard, hanger cover, header, hanger track assembly, and formed structural strut supports. Entrance design and construction must be in compliance with requirements for fire labels.
- 58.** An autodial telephone shall be furnished and installed as part of the car station. A separate phone line to the elevator controller shall be provided and located in the elevator machine room under another section of the specifications.
- 59.** Provide lobby panel in the central control room. Lobby panel to include for special emergency service, emergency power and one (1) position indicator per elevator.
- 60.** Suitable basement geared traction machine.
- 61.** Microprocessor-based dispatching and state-of-the-art VVVF AC motor control.
- 62.** The control system is variable speed PLC.
- 63.** The power of the motor is greater than (7.5 hp).

**SECTION 15400
PLUMBING**

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PART 1 - General

1.1 Scope of Work

- A. Description:** The work in this Section of the specification comprises the provision of all labor, supervision, materials, equipment, accessories, services and tests, necessary for complete plumbing systems, as shown on the drawings and as set forth in this specification, delivered to the employer in perfect operation condition.

The plumbing systems concerned shall comprise the following:

Sanitary drainage and vent pipe system.

Domestic cold water system.

Domestic hot water system.

Plumbing fixtures

Where items of equipment are specified in the singular it shall not be constructed as limiting the quantity to one, the contractor shall furnish and install the required quantity of that item indicated on the drawings.

Whenever the word “provide” is used it shall mean “furnish and install complete and ready for use”.

Equipment capacities and performance requirements shall be as listed in the schedule of equipment shown on the drawings.

- B. Civil Work:** Civil work under this Section shall include all civil work connected with the plumbing systems, such as equipment bases and supports, cutting through walls and slabs for the passage of pipes, pipe sleeves, re-patching, fixing of pipe hangers and supports to the structure, fixing of sanitary fixtures to their supporting surfaces, excavating and backfilling, the construction of reinforced concrete manholes and similar concrete structures, scaffolding, rigging, hoisting, water-proofing, cleaning, painting etc., as described in more detail under civil work.

C. General Requirements

1- Intent: The purpose of the drawings and the specification is to provide an approach for intended complete installations, finished, fully adjusted and put in perfect operating condition. All work shall be executed according to the true intent and meaning of the drawings and specification.

2- Discrepancies and Omissions: It is the responsibility of the contractor, to inform the engineer of any discrepancies in the drawings and specification before signing the contract, default of which make him responsible for any errors or omissions in the drawings and specification even through these have been approved by the engineer.

All costs incurred by any changes or alterations necessitated by any errors or omissions shall be on the contractor's own expense without having the right to ask the Employer for any indemnity.

3- Engineers' Drawings: The engineer's drawings are generally diagrammatic and include general layouts and typical details of the various systems to be installed. No deviations from the drawings shall be made without written approval from the engineer.

The drawings shall not be scaled. The contractor shall base all measurements both horizontal and vertical from established benchmarks. All work shall agree with these established lines and levels. All measurements shall be verified on site and checked as to correctness of same as related to the work.

The contractor shall check all the architectural, structural and electrical drawings in laying out work for verifying the adequacy of space in which the work will be installed. Maximum headroom and space conditions shall be maintained at all points where headroom or space conditions appear inadequate the engineer shall be noticed before proceeding with installation.

1.2 REFERENCES

A. A.R.E. Research Center for Housing, Building and Physical Planning:

1- Egyptian Code of Practice for Design and Construction of Sanitary Engineering Installations in Buildings.

2. Specifications of Plumbing Work (Sanitary Installations).

1.3 SUBMITTALS

A. Shop and Installation Drawings

Prior to starting the work the contractor shall submit to the engineer for approval detailed shop and installation drawings showing to-scale dimensions of equipment, pipes etc., in plan and elevation with clearances and relation of it to the space assigned.

Where the work will be installed in close proximity to, or will interfere with the work of other trades, the contractor shall coordinate space conditions to make a satisfactory adjustment.

The contractor shall prepare composite installation drawings and sections to a suitable scale of not less than 1/50, clearly showing how work will be installed in relation to the work of other trades.

Prior to submission of the drawings and approximately 30 days after award of contract, the contractor shall submit lists of all equipment and materials with the name of proposed manufacturers, lists shall show submission dates, the drawings will not be accepted prior to submission of such lists. Drawings of interrelated items shall be submitted at approximately the same time.

Drawings of equipment and material shall include detailed manufacturers drawings

cuts of catalogues and descriptive literature, showing specification, type, performance characteristics, construction, component parts, dimensions, size, arrangement, operating clearances, capacity, electrical characteristics, power requirements, motor drive and testing information. Data of a general nature will not be accepted.

Catalogues, pamphlets or manufacturers' drawings that submitted for approval should be clearly marked in ink for proper identification of the item being proposed.

Deviations from the specification and the drawings shall be indicated clearly with the reason for each deviation.

All submissions for approval shall be furnished in three copies and submit sufficiently in advance of requirements to allow the engineer ample time for checking and approving. Failure of the contractor to submit the drawings in ample advance time shall not entitle him to an extension of contractor time, and

No claim for extension of contract time and no claim for extension by reason of such default will be allowed.

No equipment or material shall be purchased, delivered to the site or installed until the contractor has the approved drawings for the particular equipment or material.

Approval rendered on drawings shall not relieve the contractor from his responsibility to provide equipment and material to meet the performance and quality.

Standards as indicated on the drawings and as described in the specification or are of physical size fit the space assigned for it.

Material not covered by the drawings such as pipefitting and incidentals shall be submitted for approval in letterform giving ratings and names of manufacturers.

During the progress of work drawings shall be submitted as required by the engineer and as specified elsewhere in the specification. These drawings shall comprise but not necessarily be limited to concrete bases for equipment with location of anchor bolts, manufacturer's certified installation drawings and instructions, certified performance characteristics of equipment, wiring diagrams of motor controllers and control systems etc.

The contractor shall submit for approval samples of material to be used and workmanship proposed. The contractor shall not use material or workmanship that does not correspond to the approved samples.

1.4 Quality of Equipment, Material and Workmanship

All material and equipment provided by the contractor shall be new, free from defects and of the same type, standard and quality as set forth in the specification. Equipment and material of similar application shall be of the same manufacture unless otherwise specified.

All workmanship shall be of the highest standard of the industry, of accepted engineering practice and to the entire satisfaction of the Engineer. Poor workmanship shall be rejected and the work reinstalled when, in the judgment of the engineer, the

workmanship is not the highest quality.

A. Substitution of Equipment & Material

Reference in the drawing specification to any equipment or material by name, or catalogue number, as well as any list of approved manufacturers, shall be interpreted as establishing a standard of quality and performance and shall not in any way be construed as an intention to eliminate the products of other manufactures and suppliers having approved equivalent products.

The tender shall be based on the trade name and catalogue reference named in the specification and products of the approved manufacturers. Should the contractor wish to use any equipment, material or product other than those specified he should so state as an alternative to the tender, naming the proposed substitutions and indicating difference, if any will be made to the contract. Price and detailing all differences entailed by the substitution.

At all times the engineer shall be the only judge of equality between the proposed alternative and the item specified. No alternative shall be implemented without the written approval of the engineer.

Where the contractor proposes to use equipment other than that specified or indicated which requires any redesign of the structure partitions foundations, piping, wiring or any other part of the works. All such redesign, new drawings and detailing required shall be prepared by the contractor at his own expense. All additional costs resulting from such substitution if approved by the engineer in writing shall be borne by the contractor.

Where such approved substitution requires a different quantity or arrangement of piping, wiring, conduit and equipment from that specified or shown on the drawings the contractor shall provide all such piping, structural supports, insulation, controllers, motors, starters, electrical wiring and conduits and any other additional equipment required by the system, at no additional cost to the employer.

1.5 Protection and storage

The contractor shall order all equipment from the manufacturer specifying adequate packing for export at the factory to avoid damage during shipment to the site.

The contractor shall be responsible for safe storage and the adequate protection of all material and equipment until finally installed, tested and accepted. He shall protect work against theft, injury or damage and shall carefully store material and equipment received on site in their original crates or containers until they are installed. This responsibility shall embrace any delay pending final testing of systems and equipment due to any condition.

The contractor shall close open ends of work with temporary covers of plugs during construction and storage to prevent entry of obstructing material.

The contractor shall coordinate the protection of the work of all trades and shall be liable for any damage sustained to other trades resulting from his work.

If any equipment is damaged during shipment or before it is tested and accepted, the contractor shall replace or repair the equipment, depending on the extent of damage and as determined and decided by the engineer, on the contractor's own account and without additional cost to the employer.

1.6 Coordination with Other Trades

The contractor shall plan and coordinate the work with all other trades in advance of requirements and shall provide all necessary resources to ensure compliance with the construction program.

The contractor shall coordinate the space requirements of all other trade involved and shall be responsible for the sufficiency of the size of shafts and chases and the adequate clearance in double partitions, hung ceilings etc., for the proper installation of the work.

The contractor shall give full cooperation to all trades to permit the work of the trades to be installed satisfactorily and with the least possible interference or delay.

The contractor shall furnish to other trades, as required, all necessary templates, patterns, setting plans and shop details for the proper installation and coordination of adjacent work.

The contractor shall undertake to make, without extra charge, minor changes and modifications in the layout as needed to prevent conflict with other trades work or for proper execution of the work.

Any extra cost incurred by lack of coordination on the part of the contractor shall be at his own expense.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. PVC Pipe & Fittings

All PVC pipes used shall be unplasticized of socked type for solvent welding with integral socket on one end and plain on the other end.

Ring seal joints shall be used on PVC drain where necessary to provide for expansion and contraction.

All PVC pipe size 2" smaller for above ground drainage and vent pipe systems shall conform to British Standard 3505, class D, suitable for a working pressure of 12 bars

at 20C temperature, pipe wall thickness shall be as given in the following table:

Pipe Size –(Inch)	Wall Thickness (mm)	
	Min.	Max.
1 1/4	2.2	2.4
1 1/2	2.5	2.8
2	3.1	3.4

All PVC pipe size 3”and larger used for above ground drainage and vent pipe systems shall conform to British Standard 4514, pipe and fitting wall thickness shall be as given in the following table:

Pipe Size –(Inch)	Minimum wall Thickness (mm)	
	Pipe	Fittings
3	3.2	3.2
4	3.2	3.2
6	3.2	3.5

All PVC pipe and fittings used for underground drainpipe systems shall conform to British Standard 4660. Pipe and fitting wall thickness shall be as given in the following table:

Pipe Size–(Inch)	Minimum wall thickness (mm)		
	Pipe	Fittings	Junctions(tees)
4”(110mm)	3.4	3.4	3.8
6”(160mm)	4.1	4.1	4.1

Due to the flexible properties and high coefficient of expansion of unplasticized PVC pipe it is of utmost importance that manufacturer’s instructions be closely followed in the installation of both above ground and underground piping and in its handling and storage.

Ring seal joints shall be provided at adequate intervals as recommended by the manufacturer to take care of expansion and contraction. A minimum of 10mm allowance for expansion shall be left between end of pipe and bottom of socket. Rubber sealing rings supplied with the pipe or fittings shall comply with BS 2494,

part2.

The internal and external surfaces of the pipe and fittings shall be clean, smooth and reasonable free from grooving and other defects that would impair their performance in service.

The ends of the pipe and fittings shall be cleanly cut and square with the axis of the component. The pipe shall be reasonable straight.

Special adapters shall be ordered from the manufacturer for connecting PVC pipe and fittings to pipe of other materials such as cast iron, galvanized steel, copper, pitch fiber, asbestos cement, glazed fire clay other plastic materials.

Solvent weld joints in PVC pipe shall be made with the proper solvent cement furnished by the manufacturer for the purpose.

Both the insides of the socket and the outside of the pipe to the depth of entry shall be roughened using sand paper or emery paper. All grease and dirt shall be removed from the mating surfaces with a special cleaning fluid supplied by the manufacturer for the purpose using clean dry cloth made from natural fibers. The cloth shall be used only once using new cloth for cleaning every successive joint.

Immediately after cleaning, solvent cement shall be applied in an even unbroken layer to the inside of the spigot and the outside of the pipe in an axial (down the pipe) direction using a clean flat brush.

A thicker coating shall be applied to the spigot of the pipe. The pipe shall be immediately slide into the socket until it bottoms and shall be held in position for a few seconds and excess cement wiped off. After jointing, the joints shall not be disturbed for at least 15 minutes and shall not be installed for at least 4 hours. The pipes shall not be pressures tested until after 24 hours have elapsed from the time of making the joint.

PVC pipes shall be handled with care to prevent damage to the pipes especially to the socked ends. Pipes shall be stored in the shade; adequately supported at all times along their entire length on level ground free from loose stones and shall not be stacked more than three layers high to prevent the bottom pipes from distorting. Sockets shall be placed at alternate ends of the stack and protruding beyond the pipes. Pipes stored in stacks shall be stacked to prevent movement.

Above ground PVC pipes to BS 3505 shall be supported at intervals not to exceed the maximum spacing as given in the following table:

Pipe size –(Inch)	Maximum Support Distance-cm.	
	Horizontal Pipes	Vertical Pipes
½	600	120
¾	70	140
1	75	150
1 ¼	80	160
1 ½	90	180
2	105	210
3	135	270
4	150	300
6	80	360

B. Galvanized Steel Pipe and Fittings

All galvanized steel pipe used shall be seamless or welded as specified under the respective plumbing system concerned, and shall conform to British standard 1387, medium class, ISO/R65 OR DIN 2440 Standards.

Galvanized steel pipe wall thickness and weight shall be as given in the following table:

Pipe (Inch)	Size (mm)	Thickness(mm)	Weight of Plain End Corresponding Black Pipe Kg/m
½	15	2.65	1.22
¾	20	2.65	1.58
1	25	3.25	2.44
1 ¼	32	3.25	3.14
1 ½	40	3.25	3.61
2	50	3.65	5.10
2 ½	65	3.65	6.51
3	80	4.05	8.47
4	100	4.50	12.1
5	125	4.85	16.2
6	150	4.85	19.2

Galvanized steel pipe shall be galvanized at the factory by dipping in a bath of molten zinc, containing not less than 98.5% by weight of zinc, at a temperature suitable to

produce a complete and uniformly adherent coating of zinc. The galvanizing shall be capable of passing the test described in Appendix A of British Standard 1387: 1967.

All changes in direction, changes in pipe size, branching and jointing of pipes shall be made with regular pipe fittings such as elbows, reducers, tees, couplings, unions, flanges, etc., bending of pipes for elbows and field fabricated fittings such as metered elbows, tees or reducers will not be permitted. Bushings, close nipples and straight elbows shall not be used.

Reducers shall be of the concentric or eccentric type as indicated on the drawings to suit the application. Elbows shall be of the long radius type.

Galvanized steel pipes shall be joined by threading for all sizes. Welding of galvanized pipes will not be permitted.

All fittings used on galvanized steel pipes shall be screwed, galvanized malleable iron of 150 PSI steam working pressure rating and shall be of the banded type. Plain ended or black fittings will not be permitted.

All threads used on pipes shall conform to British Standard Taper pipe Thread BS 21.

Pipes shall be cut square and to the exact length with a hacksaw and the cut end of the pipe shall be reamed with a special tool to the full inside diameter and all chips removed. Threads shall be cut with new dies and all burrs and chips formed in the threading operation shall be removed with wire brush.

Threaded joints shall be made up tight with Teflon tape thread sealant or any approved special jointing compound suitable for the application. Red lead, lamp wick, cord, wool or any other similar material will not be permitted in making up threaded joints.

Horizontal steel pipes shall be supported at intervals not to exceed the maximum support spacing as given in the following table:

Pipe Size	Maximum Support Spacing-m
½"	1.5
¾"	1.8
1"	2.0
1 ¼"	2.5
1 ½"	2.7
2"	3.0
2 ½"	3.3
3"	3.6
4"	4.2
5"	4.8
6"	5.2

Vertical steel pipes shall be supported at a minimum of every story height.

C. COPPER TUBES

It shall be in copper tube to BS 2871 part 1 Table X and manufactured from de-oxidized arsenical copper to BS1172. Copper tube shall carry the Manufacturer's identification marks. Capillary and compression fittings for copper pipe work shall conform to BS 864:1971 part 2 and any subsequent amendments fittings marked 864.2 or 844.4 shall be used.

For pipe work up to 54mm nominal bore, fittings shall be of the capillary type. Fittings on pipe work of 67mm diameter shall be silver soldered, but bronze welded joints may be employed wherever practicable. Capillary fittings shall be gunmetal with rings or solder at each joint. All capillary fittings are to be assembled in accordance with the Manufacturer's instructions. All fittings shall be formed of metals not subject to dezincification.

All horizontal pipe work shall be graded to falls for air elimination and to enable the entire system to be self-draining. Approved type "A" drain cocks must be installed all low points whether shown on drawings or not.

In unavoidable high points which are not self-venting, approved air bottles and cocks must be provided in a permanently accessible position.

Joints shall not be made in the thickness of any wall or floor.

All copper tube in contact with the soil or building fabric shall be protected by being twice wrapped in denso tape or similar and equally approved.

Pipe sleeves shall be fitted where pipes pass through walls and floors. The sleeves to be of similar material or as stated on the Drawings and be of sufficient diameter to allow free movement of the pipes. Where sleeves are passing through external walls or fire barriers they shall be caulked with approved non-setting "intacaulk" compound or fire proofing material to provide an effective permanent waterproof and fireproof seal.

All pipe work shall be adequately supported on approved hangers or brackets and a pipe clip in contact with the copper pipe must be brass. The pipe supports shall be to the following centers:

Pipe size	Minimum Spacing on	Minimum Spacing on Vertical
	Horizontal Pipes	Pipes
15mm	1.2m	1.8m
22mm	1.2m	2.5m
28mm	1.5m	2.5m
32mm/35mm	1.5m	3.0m
42mm	1.8m	3.0m
54mm	1.8m	3.0m
65mm/76mm	2.1m	3.7m

108mm	2.5m	3.7m
133mm	2.8m	4.6m
159mm	2.8m	4.6m

D. Stainless Steel Pipe (S.S.) for drainage

Supply, install and test (S.S) pipes (grade 304) for drainage of liquids with high temperature , according to ASTM A194 working pressure 6 bar.
Complete with Fitting, Solvent weld material and of approved manufacturer.

E. HDPE Pipes for drainage

Supply, install and test high density poly ethylene (HDPE) pipes for drainage, in accordance with BS 6572 Or DIN 8074 – 8075, working pressure 6 bar, jointing shall butt welding or electric fusion couplings. Complete with Fitting, welding, and of approved manufacturer as (Technoplast for Plastic Industries SAE).

Out side diameter	Wall thickness
110 mm	6.3 mm
160 mm	9.1 mm

2.2 Plumbing Fixtures

A. Lavatory-Type (wall hung)

White vitreous China lavatory 70x58cm, with three holes for taps and mixer, complete with wall brackets, Ideal Standard Model CONCA or approved equal.

Lavatory shall be complete with the following trim and accessories, or approved equal:
Chrome plated mixer consisting of ½’ taps, 16cm high nozzle and 1 ¼” pip-up waste, Ideal Standard ceramic basin mixer.

Chrome plated 1 ¼” P-trap with wall tube and wall flange, adjustable type, Ideal Standard No. A8100.

Chrome plated ½’ angle supply and stop valve with 30cm long tube, blue index. Ideal Standard No. A 4303974162.

Chrome plated ½’ angle supply and stop valve with 30cm long tube, red index. Ideal Standard No. A 4303974162.

B. Water Closet Western Type

White vitreous China European water closet, floor mounted, P-trap close coupled to flush tank, Ideal Standard Model CONCA, or approved equal.

Water closet shall be complete with the following trim and accessories, or approved equal:

Black solid plastic seat and cover complete with metal hinge, rubber washers and

plastic screws, and nuts, Ideal Standard No.GS 6725 Standard.

Chrome plated 3/8" angle supply and stop valve with 30cm long tube, blue index. Ideal Standard no A.4301012.

Vitreous China toilet paper holder, recessed type, 15x15cm, Ideal Standard, No.EF 8804

C. Water Closet Eastern Type

White vitreous China eastern water closet, S-trap close coupled to flush tank, LECICO, or approved equal.

Water closet shall be complete with the following trim and accessories, or approved equal:

Eastern Style water closet shall be furnished with integral non-skid foot pads and bowl wash down non-splashing flushing rim. The water closet shall be completely self supporting requiring no external mounting hardware and shall be flush with floor. The Eastern Style water closet shall incorporate waterproofing membrane flashing flange. Provide a cold water spigot/hose bib, only 300 mm above finished floor on the right (from a perspective of standing inside of the cubicle and looking out) sidewall of the cubicle.

D. Shower – Tray

Shower shall be enameled cast-iron complete with the following trim and accessories, of size 80 x 80 cm, complete with:

Chrome plated 2" waste fitting with strainer.

Shower mixer composed of two stop valves 15mm, shower spray bracket and flexible hose, all of approved sample.

Vitreous China soaps holder with hand rip bar, recessed type, and 30x15cm. Ideal Standard No.GD. 9505.

E. Kitchen Sink

Stainless steel kitchen sink, of the inset type for fixing into a counter top, 16 gauge minimum thickness of metal, with 10cm high splash back. Stainless steel shall be type 302. The sink shall be as manufactured by Franki, or approved equal.

Kitchen sink shall be complete with the following trim and accessories, waste fitting, plug and chain, in brass chromium plated brass.

Bottle trap 50mm with water seal 50mm.

Kitchen mixer of approved pattern.

F. Urinal

Complete urinal, wall hung white color of approved manufacturer complete with waste fitting and trap, and flush valve 15mm of approved manufacturer.

G. BATHROOM ACCESSORIES

General: All toilets accessories shall be stainless steel, of approved samples and from well known manufacturers as (FRANKI) or approved equal.

1. Toilet paper holder, for wall mounting stainless steel, surface satin finished per each WC, as Sample (BS677).
2. Hand dryer, touch free electronic warm for wall mounting, stainless steel, as sample (STRX210).
3. Hook ,for wall mounting, stainless steel, surface satin 18 mm pipe diameter, as sample (STRX692).
4. Mirror ,for wall mounting, made of crystal glass (glance 60) stainless steel, 6 mm,4 mounting supports stainless steel as sample (XINV600).
5. Shelf ,for wall mounting, stainless steel, rounded edges as sample (XINV623).
6. Soap dispenser ,for wall mounting, stainless steel, as sample (XINV616).
7. Paper towel dispenser ,for wall mounting, stainless steel, as sample (XINX630).
8. Waste bin ,for wall mounting, stainless steel, as sample (XINX607).
9. Ashtray ,for wall mounting, stainless steel, as sample (XINX640).

H. SERVICE SINK

Shall be stainless steel type, of size about 900 x 900 mm, 50 mm adjustable “S” Trap with cleanout plug, strainer complete with waste and water supply connections. As sample (BS401).

2.3 MISCELLANIOUS Fixtures

A. FLOOR DRAINS

1- PLASTIC FLOOR DRAINS: The floor drain shall be of outlet size Φ 50 or Φ 75 mm, with water seal < 50mm, All in ABS and of approved manufacturer (Kessel) or approved equal.

2- STAINLESS STEEL FLOOR DRAINS: The stainless floor drains shall be installed in the production area and as indicated on drawings.

The floor drain shall be manufactured from grade 304 stainless steel, with water seal <

50mm, with circular grating in a 100mm square top and outlet size 110mm or 75mm. Approved manufacturer: (ACO Fulbora) or approved equal.

B. ROOF DRAINS

The Roof rain water drain shall be in plastic body (UPVC), with strainer, Outlet size shall be of approved pattern as manufactured by ABLACO, Kessel or approved equal

C. MANHOLES

Manholes shall be of poured in place plain construction with dimensions and details as shown on the drawings.

Manholes shall be constructed to the required depth. The manhole top shall have a 56cm round opening and square recess shaped to accommodate a cast iron cover and frame as specified.

Manhole floors shall be formed by hand with rich cement mortar to the size and shape of the sewer. Inverts shall have a cross section of exact shape as the sewers and all changes in sewer size shall be made gradually and evenly. The floor shall have a gradual slope from the sidewalls to the central channel. Half pipe inverts may be used in straight through manholes.

The main and side inlets shall have a normal drop of 5 to 8cm above the bottom of the central channel.

The manhole internal walls shall be plastered with two coats of cement mortar, one part cement to three parts sand, to a total thickness of 1.5cm.

During construction of the manhole, galvanized pipe steps shall be furnished and set in place on the inside wall beginning 60cm above the bottom and spaced at approximately 35cm center to center. They shall be properly embedded in the wall.

All work shall be carried out in a manner to ensure watertight construction if leaks occur they shall be caulked, repaired or the entire work shall be removed and rebuilt. Attention shall be particularly paid to the necessity of keeping the water level below all parts of the manhole until the cement has obtained adequate set.

D. COVERS AND FRAMES

Access openings to underground structures shall be provided with cast iron covers and frames of dimensions and detail as shown on the drawings.

Covers and frames shall be in accordance with Bs 497, grade b, and medium duty, with square frame and circular cover.

Covers and frames shall be cast of Grey iron of a quality not less than that specified in BS 1452. All castings shall be sound and free from voids, air holes, sand holes and other imperfections. Castings shall be made accurately to dimensions and machined to

provide even bearing surfaces.

Covers and frames shall be supplied from the factory coated inside and out with a tar or bitumen based composition which shall be smooth and tough and which shall not flow or chip when exposed to temperatures of between zero and 62deg.C.

Covers shall fit the frames in any position and if found to rattle under traffic shall be replaced, No plugging, burning in or filling to obtain tight covers will be allowed.

The recess in the concrete masonry for the cover and frame shall be neatly and accurately made to the dimensions of the frame. The frame shall be thoroughly embedded in mortar and frame and cover set level and to the proper grade.

E. ELECTRIC WATER HEATER

The electric water heater shall be of the thermal storage, high pressure, and wall mounted, cylindrical type with bottom inlet and outlet connections.

The heater shall have the storage capacity and wattage rating as shown on the drawings.

The electric water heater shall comprise an inner water container, outer casing, end covers, thermal insulation, two electric immersion heaters, two thermostats, safety unit and wall mounting brackets.

The water container shall be constructed of heavy gauge submerged arc-electric welded steel designed for a working pressure of 6 bar hydrostatically tested to 12 bar at the factory. The container shall be lined on all surfaces in contact with water with a copper of 3 lbs/sq. ft.

The outer casing and end covers shall be of heavy gauge sheet steel adequately treated to combat rust and smoothly finished with baked-on hardwearing white stove enamel.

The space between water container and outer casing and end covers shall be filled with polyurethane foam insulation for minimum heat loss.

The heater shall be provided with two immersions type electric heating elements with titanium sheets. The heating elements shall be removable without draining the water container. Each heating element shall be equipped with a separate conductor and high limit temperature control to cutout the electric supply in the event of overheating.

The immersion heaters shall comply with BS 3465: Section 2.21.

Each heating element shall be controlled by a separate and adjustable thermostat of the immersion type with a temperature adjustment range of not less than 90 to 189 degs. F and a current rating of not less than 20 Amp. The thermostats shall comply with BS3955: Section 2B.

Means shall be provided in the outer casing for the entry of a 1” electric conduit for the electric connections.

The heater shall be fitted with a safety unit comprising an expansion relief valve pre-set at 7 bar, non-return valve, stopcock and drain.

Approved Manufacturers: IMI Santon Ltd. (U.K.) Or approved equal.

2.4 DESIGN CRITERIA

A. GENERAL REQUIREMENTS, PIPING

1- Pipes shall be of sizes and general routing as indicated on the drawings. Valves shall be of the same size as the pipe run in which it is installed.

Piping material shall be as specified under the respective systems for the particular system concerned.

Pipes shall be installed in a neat manner to present a neat and pleasing appearance. Vertical pipes shall be installed in plumb vertical lines and horizontal pipes in pitched horizontal lines to allow the piping system to be properly vented and drained.

Pipe slopes shall be as specified under the respective systems and/or as indicated on the drawings.

Pipes shall be grouped together as much as is practicable and shall be run in straight parallel lines close and parallel to walls, ceilings and columns for protection against damage.

Adequate clearances shall be left between adjacent pipes and between pipes and walls, ceilings and columns for making the joints properly, for the easy installation and removal of valves and accessories and for proper installation of insulation.

Concealed piping shall be installed in a manner to permit easy accessibility for maintenance and repair. This applies particularly to the location of valves, vents, drains and other accessories.

Piping shall be installed in a manner to avoid air pockets and dirt traps. Pipe supports shall be spaced at close enough intervals to avoid sags. Eccentric reducers shall be used where appropriate to avoid air pockets. On water piping the flat of the eccentric reducer shall be installed on top to permit proper venting of the system.

Piping shall be installed in a manner to permit free expansion and contraction without causing damage to piping or construction. Adequate offsets and changes of direction in the piping shall be provided to accomplish this. On long pipe runs expansion loops or expansion joints shall be provided as indicated on the drawings.

Where expansion joints are used, careful consideration shall be given to anchoring and guiding the pipes for controlled expansion and contraction. The instructions of the manufacturer of the expansion joints shall be carefully followed in locating expansion joints, anchors and guides.

Manual drain valves shall be provided at all low points of water piping systems irrespective of whether are indicated on the drawings or not to permit draining any part of the system for maintenance and repair. Drain valves shall be of the gate valve type of $\frac{3}{4}$ " minimum size. Where necessary drain valves shall be provided with brass, serrated hose connections at their outlet.

Manual air vents shall be provided at all high points of water piping systems irrespective of whether they are indicated on the drawings or not to permit venting any air collected at the high point that tends to obstruct flow. Manual air vents shall be of the globe valve type of $\frac{1}{2}$ " minimum size.

Automatic air vents shall be provided where indicated on the drawings for venting the air automatically from the high points of the system.

Isolating valves shall be provided on all branches of water piping systems irrespective of whether they are indicated on the drawings or not to permit closing of any section. Of the system for maintenance and repair without interrupting other parts of the system. Isolating valves shall be of the gate valve type.

Gate valves shall not be used for throttling purposes such as regulation, balancing or control. For such service a globe valve shall be used. Gate valve shall only be used for shut off purposes where the valve is either fully closed or fully open.

Wherever a globe valve is installed in a piping system for throttling purposes a gate valve shall also be provided up stream of it so that if a section of the piping system is to be isolated the gate valve can be used without disturbing the setting of the globe valve.

Pipe unions or flanges, depending on size and material of piping, shall be provided at piping connections to equipment and near valves, controls, strainers and other accessories that need to be taken out for replacement, cleaning or repair.

Unions or flanges shall also be provided at adequate intervals in the piping to permit easy disassembly for alternations and repair.

Piping connections to moving equipment shall be made through flexible connections to reduce the transmission both sides of equipment. Any reduction in pipe size shall be made right at the equipment and valves, flexible connections and other accessories shall be the full pipe size indicated on the drawings.

Piping connections to equipment shall be arranged in a manner to permit easy removal of the equipment for servicing without disturbing the piping. At the same time the piping shall not interfere with the removal of equipment or parts thereof. The unions or flanges shall be installed between the equipment and the isolating valves.

Strainers shall be provided upstream of equipment such as pumps, control valves etc. For protecting the equipment from suspended particles or collected dirt that can damage or interfere with the proper functioning of the equipment.

Relief valves shall be provided where indicated on the drawings, of size and pressure setting indicated, for protecting equipment or piping against over pressure from any cause.

Pressure gauges and thermometers shall be provided on equipment or piping as indicated on the drawings or as directed by the engineer.

Check valves used on the discharge of pumps shall be on the silent, non-slam, spring-loaded type or of the swing type fitted with weight and lever as indicated on the drawings for reducing water hammer and surge when the pump stops.

Special care shall be exercised in installing threaded valves to avoid straining their bodies and preventing the gate or seat from closing tight. The wrench shall always be applied to the valve end that is being attached to the pipe. When attaching a pipe to a valve that is already in place a second wrench shall be used on holding the valve while the pipe is being tightened. A pipe shall not be screwed too far into a valve so as not to damage the seat.

2- UNIONS: Unions used on threaded pipes size 2" and smaller shall have female threaded ends and ground metal to metal seats. Unions shall be of the same manufacture, pressure class and material as the other pipefitting specified for the system concerned.

3- FLANGES: Flanges shall always match the flanges provided on valves and equipment as far as pressure rating, facing, drilling and thickness. Flat face flanges shall never be mated with raised face flanges.

Flanges on black steel pipes shall be black, forged steel of the slip-on or welding neck type. Flanges on galvanized steel pipes shall be galvanized steel of the threaded type.

Flanged joints shall be made perfectly square with the pipes and shall be fitted with 1.5mm thick asbestos composition ring gaskets and assembled with steel, square head machine bolts and hexagonal nuts, the bolts shall be of diameter and length to suit the flanges and to allow the nuts to utilize the full length of their thread.

Gaskets for flat face flanges shall be of the full-face ring type with punched bolt holes.

4- JOINTS BETWEEN DISSIMILAR METALS: Joints between dissimilar metals shall be made through dielectric insulated unions and flanges to prevent electrolytic interaction and corrosion. This applies particularly to joints between ferrous and nonferrous piping.

Insulating unions shall be used on threaded piping and insulating flanges on welded piping. Flanges shall be fitted with insulating gaskets and Teflon sleeves and washers between flanges, nuts and bolts.

The entire insulating joint including the dielectric material shall be suitable and capable to withstand the temperature, pressure and all other operating conditions of the service for which they are used.

Approved Manufacturers:

- Aeroquip Crop. (U.S.A.)
 - Capito Mfg. Co. (U.S.A.)
 - Dresser (U.S.A.)
 - The Duriron Co. (U.S.A.)
 - Epco Sales, Inc. (U.S.A.)
- Or approved equal.

5- VALVES: All valves used shall be of 8.5 bar steam working pressure rating and 13.6 bar water non-shock pressure rating.

All gates and globe valves shall be of type that can be repacked under pressure. Threaded valves shall be supplied with British Standard Taper pipe thread.

Gate valves size 2" and smaller shall be screwed, bronze body and trim, solid wedge disk, non-rising stem, bolted bonnet.

Gate valves size 2 1/2" and larger shall be flanged, cast iron body, bronze trim, solid wedge disk, non-rising stem bolted bonnet.

Globe valves size 2" and smaller shall be screwed, bronze body and trim, integral seat, revolving disk, inside screw, screwed bonnet.

Globe valves size 2 1/2" and larger shall be flanged, cast iron body, bronze trim, renewable seat and disk, outside screw, bolted bonnet.

Check valves size 2" and smaller shall be screwed, bronze body and trim, swing pattern, renewable composition disk, screwed cap.

Check valves size 2 1/2" and larger shall be flanged, cast iron body, bronze trim, swing pattern, renewable seat, bolted cap.

Approved Manufacturers:

- Crane Co. (U.S.A. or U.K.)
 - Jenkins Bros. (U.S.A.)
 - Kennedy Valve Mfg.Co. (U.S.A.)
 - Walworth. (U.S.A.)
 - Lunkenheimer. (U.S.A.)
 - Nibco. (U.S.A.)
 - Newman-Hattersley. (U.K.)
- Or approved equal.

Approval of a manufacturer does not necessarily constitute approval of his valves as equal to those specified. After award of contract and before start of construction the contractor shall submit for the approval of the engineer a complete summary of valves proposed to be furnished indicating service, manufacturer, figure number, type and

pressure rating.

6- PIPE HANGERS & SUPPORTS: All piping shall be supported on steel hangers and supports of adequate strength and design to carry the weight of piping and concrete without sagging, swaying, vibrating, failing or deforming, and to allow free movement of pipes due to expansion and contraction without causing noise, damage to piping or to construction.

Pipe hangers and supports shall be of the approved types as detailed on the drawings and of component sizes as given thereon. Hangers and supports shall be provided complete with all necessary structural steel, rods, bolts, nuts, turnbuckles and all other necessary components.

The use of wire, metal bands, rope, wood, chain, straps; perforated bar or any other makeshift device for supports will not be permitted. Hanging pipes from other pipes will not be permitted.

Pipe hangers and supports shall have smooth flat bearing surfaces, free from burrs or other sharp projections, which would wear or cut into the pipe.

Hangers and supports shall be of a design that allows adjustment of the required slope in piping and that permits removal without dismantling the pipes.

The contractor shall submit shop drawings of all pipe hangers and supports that he proposes to use to the engineer for approval. Early priority shall be given to the selection and procurement of pipe hangers and supports, during the layout phases of design, to properly coordinate their installation with the piping erection schedule. Embedded attachments such as inset in concrete shall be provided during the concrete pouring operations.

The use of temporary hangers and supports, due to failure of allowing sufficient time for the procurement, design and fabrication of the proper hangers and supports, will not be permitted and the contractor shall bear all consequences of erection delays resulting there from.

Approval by the engineer of the contractor's shop drawings shall not relieve the contractor of his responsibility to provide proper hangers and supports capable of completely satisfying the system requirements and job specifications.

Hangers and supports shall be of design and strength to met all static and operational conditions to which piping and equipment may be subjected. The calculations for determining the loads at each hanger or support for selection the proper type and size of components shall take into account the weight of pipe, valves, fittings, insulating materials, suspended hanger components, all appurtenances and the weight of the normal operating contents. In addition, the extra loading due to pipe expansion and contraction, vibrations from equipment, hydrostatic testing, water hammer, seismic forces, reaction forces etc. Shall be taken into consideration.

Pipe hangers and supports shall be located, in addition to the maximum spans

specified under the respective pipe material, taking into consideration concentrated loads, elimination of overhung sections or bends and load reaction on terminal connections.

The specified maximum spans between hangers and supports are for straight runs of pipe and do not apply where concentrated loads such as the weight of valves or heavy fittings exist, where changes of direction in the pipe occur between hangers and supports, hangers and supports shall be placed as close as possible to concentrated loads. Where changes in direction or branch connections occur, the spacing between hangers and supports shall be reduced to less than three-fourths of the maximum spans specified. A hanger or support shall be located immediately adjacent to any change in direction of the piping and at every branch connection. Risers shall be supported independently of adjacent horizontal hangers.

Where a horizontal pipe is subject to considerable movement in the vertical direction or is subject to vibration from moving equipment, spring cushions of detail shown on the drawings shall be used.

Piping shall be supported independently of equipment not to cause the equipment to be stressed by piping weight or pipe expansion and contraction.

Piping shall be routed to use the surrounding structure for support, anchorage, guidance or restraint, with adequate space provided for use of the proper hanger or support, parallel lines, both vertical and horizontal, shall be spaced sufficiently apart to allow room for independent pipe attachments for each line.

Multiple pipe runs where the bottoms of the various lines are approximately at the same elevation shall be supported in-groups on a trapeze hanger with provisions made to keep the lines in their relative positions to each other by the use of U-bolts. Lines subject to extreme thermal expansion shall be free to slide or to roll.

Hangers and supports shall be securely fastened to the building structure by means of masonry expansion bolts without causing overstress to any part of the construction. Intermediate steel shall be provided where required to transfer the loads to areas where they can be accommodated safely. Hangers and supports shall be designed and tested to sustain a load 8 times the actual supported load.

Masonry expansion bolts shall be of minimum 20mm diameter and of an approved make. They shall be drilled for in the concrete and shall be installed in accordance with the manufacturer's instructions.

On insulated pipes, special provisions shall be made at the point of support to prevent damage to the insulation due to pipe weight or movement and to provide a firm attachment of the pipe.

On hot insulated pipes, pipe protection saddles shall be used as detailed on the drawings. The saddle shall be 30cm long and of approximately 60deg. Of arc. The metal thickness shall be at least 3mm for pipe sizes of up to 5" and 5mm for larger pipe sizes. Directly on the pipe and the arms of the clamp extended outside the

insulation of a larger hanger of cleaves or pipe clamp type may be used lined with insulation protection shields.

The length and metal thickness of insulation protection shields for different pipe sizes shall be as given on the drawings.

Hangers and supports for individually supported, straight run the respective pipes or different material.

The maximum spacing of trapeze hangers for multiple pipes shall be the maximum spacing for the smallest pipe on the trapeze.

7- ANCHORS: Pipe anchors shall comprise a U-bolt of ¾" diameter shaped to fit the pipe and welded to it at all points of contact. The U-bolt shall be bolted to an adequate structural angle frame, which is securely fastened to the building structure.

8- GUIDES: Pipe guides shall be constructed the same manner as anchors except that the U-bolt shall fit loosely around the pipe instead of being welded to it.

9- ACCESSIBILITY: All work shall be installed so as to be readily accessible for operation; maintenance and repair. Deviations from the drawings may be made to accomplish this, after the written approval of the engineer.

Concealed valves and devices shall be grouped together in as practical a way as possible in order to be accessible through access doors.

10- ACCESS DOORS: The contractor shall arrange for access doors and frames to be provided for easy access to concealed equipment, controls, valves, traps, vents, drains, clean-outs and other devices that require periodic operation, inspection or maintenance.

Access doors and frames are provided under another trade.

However, the dimensions and locations of access doors shall be the responsibility of the contractor and shall have the approval of the engineer before the work is installed.

Requirements of access doors shall be submitted in sufficient advance time to be installed in the normal course of the work.

Contractor shall be responsible for the correct identification of access doors by means of tapes or markers to indicate the location of concealed work. The engineer shall approve the method and schedule for identification of access doors.

11- NAMEPLATES: Each piece of equipment provided shall carry, at attracting location, attached in a permanent manner to the equipment at the factory, a certified nameplate on which shall be printed clearly the name and address of the manufacturer, the equipment model number, serial number, date of manufacture, electrical characteristics, performance rating or duty, pressure, temperature or other limitations and all other pertinent data as deemed necessary by the manufacturer for any future reference to the equipment.

12- LABELING: The contractor shall label and identify all equipment, instruments, controls, electrical devices, valves etc. as to duty, service or function.

Labels shall be attached to equipment, instruments, controls, electrical devices etc. or to adjacent permanent surfaces, in an approved permanent manner.

The contractor shall submit to the engineer for his approval prior to installation schedule of all equipment and devices to be labeled and the suggested nomination.

Controls and electrical devices shall be labeled to indicate clearly which equipment they control.

Controls and instruments that cannot be identified easily with Bakelite labels shall have tags attached to them.

13- TAGS & CHARTS: Tags shall be provided on valves and controls except equipment shut off valves located at the equipment. Tags shall consist of 5cm diameter by 15mm thick aluminum sheet with stamped numbers and letters filled with black paint. Tags shall be attached by heavy aluminum or brass hooks or chains.

Charts shall be prepared of schematic flow diagrams of each piping system with location and function on each tagged valve and with type and size of each essential feature of the system. Charts shall also be prepared for equipment lubrication and maintenance schedules equipment essential operating instructions and as directed by the engineer.

Charts shall be mounted on wooden plaques or on 6mm thick Masonite boards and covered with heat bonded clear plastic laminate or framed under glass. Charts shall be permanently fastened with four brass screws at locations as directed by the Eng.

Copies of all charts prepared shall be included in the operation instruction manuals.

All tags and charts shall be submitted to the engineer for approval prior to final installation.

14- RECORD DRAWINGS: The contractor shall submit to the engineer for record a complete set of as-built drawings and electrical wiring diagrams, in tracing or other reproducible form, reflecting all the changes made from the original drawings. During the progress of the work. The drawings and electrical wiring diagrams shall show all labeled equipment, valves controls, instruments and electrical devices.

B. GENERAL REQUIREMENTS, DOMESTIC HOT-WATER SYSTEM

PIPE INSULATION: All hot water supply and return pipes shall be insulated with 25mm thick, performed, rigid, sectional, fiberglass pipe insulation, specially supplied for the nominal pipe sizes concerned. The insulation shall have an average thermal conductivity not to exceed 0.32 Btu-in per sq. ft per degree F per hour at a mean temperature of 75 deg. F and a minimum density of 5 lb per cu ft.

Fittings, valves and flanges shall be insulated with fiberglass blankets, of minimum density of 1 lb per cu ft, wrapped firmly under compression in a minimum ratio of 2:1 to obtain a thickness equal to that of the adjoining pipe insulation and tied with

galvanized annealed steel wire.

All insulation shall be over wrapped with a muslin jacket neatly lapped and pasted on with special adhesive to present a neat, clean and pleasing appearance. Kraft paper shall be used where necessary to provide a smooth surface for the installation of the muslin jacket.

Installation of pipes run underground or outdoors shall be waterproofed by wrapping the insulation with two layers of 15 lb, asphalt-impregnated roofing felt, wired in place and well mopped with an approved air-setting asphalt compound between each layer and finished with a thick layer of the same compound on the outside.

All insulation shall be the product of a reputable manufacturer such as 'Johns-Manville' 'St. Gobain' 'Fiber Glass Ltd.' or approved equal.

All insulation work shall be executed in a workmanlike manner by skilled workmen regularly engaged in this type of work.

Insulation shall not be applied until after the pipes have been tested, approved and accepted.

Before insulation is applied, pipe and fitting surfaces shall be thoroughly cleaned of all paint, scale, oil, grease or any foreign matter. Insulation shall be applied on dry surfaces.

All insulation shall be continuous through sleeves, hangers and supports. Galvanized sheet metal shields of 1mm thickness and 30cm long shall be applied between hangers and supports and pipe insulation to prevent depressing of the insulation.

C. GENERAL REQUIREMENT SANITARY DRAINAGE & VENT PIPES SYSTEM

1- SANITARY DRAINAGE AND VENT PIPE SYSTEM: shall be executed in accordance with the American Standard National Plumbing Code and as shown on the drawings.

All drainpipes shall be UPVC pipes.

Horizontal drainpipes shall be laid at a uniform slope of not less than 1% and not more than 3%.

All changes of direction in drainpipes shall be gradual and not abrupt. Long sweep fittings and 45-degree fittings shall be used. All unnecessary turns and offsets shall be carefully avoided and the drains shall be run as direct as possible from the sanitary fixtures to the vertical stacks.

All vent pipes extending above the roof shall pass through sleeves, which shall be flashed and waterproofed as detailed on the drawings.

The sanitary drainage and vent pipe system shall be tested as described under "Testing, Balancing & Adjusting".

2- CLEANOUTS: Cleanouts shall be provided on all drainpipes for the purpose of

cleaning blocked pipes.

Cleanouts shall be provided where shown on the drawings, at or near the foot of every vertical stack and on long horizontal pipe runs at every 15m interval.

Cleanouts on exposed pipes shall be installed directly on the pipe. Cleanouts on concealed pipes shall be extended through and terminated flush with the finished floor or wall and concealed in a manner to be approved by the engineer to match the surrounding finished surface.

Cleanouts in the floor or in the wall shall be concealed with access covers or panels consisting of 7"x7" square frame with anchor lugs and cover plate secured with screws. The frame and cover shall be of polished nickel bronze with smooth finish.

The access cover shall be manufactured by 'Zurn' No.Z-1460, 'Josem' No.Y-L92-BB, or approved equal.

3- VENT COWLS: All vent pipes extending above the roof shall be provided with vent cowls to prevent the entrance of bird's insects and vermin. Vent cowls shall consist of galvanized wire basket screens with round inlets to fit snugly inside the open end of the vent pipe as detailed on the drawings.

D. GENERAL REQUIREMENTS, PLUMBING FIXTURES

1- The contractor shall furnish and install all the plumbing fixtures as shown on the drawings and as specified below complete with all their trim, accessories and supports as specified. Prefix numbers identity and locate the fixtures on the drawings relative to the fixtures described herein.

Plumbing fixtures shall be of vitreous china of the first quality and of color as specified. Fixtures shall have smooth glazed surfaces free from warp, cracks, checks, flaws, discoloration or other imperfections. Imperfect fixtures will not be accepted.

All vitreous China accessories shall match the plumbing fixtures and shall be of the same manufacture and color.

All plumbing fixtures, trim and accessories shall be the product of a reputable and approved manufacturer and as far as practicable shall be procured from manufacturer unless specified otherwise.

Plumbing fixtures and their trim and accessories shall be installed in a neat finished and uniform manner as directed by the engineer. They shall be set straight and true and securely attached to the supporting surfaces. Roughing shall be accurately laid out to conform to finished walls and floors.

Plumbing fixtures shall be connected to the drain and water supply pipes in an approved gaslight and watertight manner.

Strap or padded wrenches shall be used on chrome-plated pipe, fittings, valves and other trim.

Immediately after installation, an ample coating of petroleum jelly shall be supplied to all exposed surfaces of chrome plated piping, valves fittings and other trim for protection until final acceptance.

Plumbing fixtures, metal trim and accessories shall be thoroughly cleaned of labels, plaster, paint dropping and all foreign matter and shall be well polished and tested for perfect working condition before turning them over to the employer.

Concealed brackets, hangers and plates shall be painted as directed by the engineer.

The contractor shall submit to the engineer a list of all plumbing fixtures, trim and accessories that he proposes to use indicating manufacturer, type and model number, with descriptive catalogues clearly marked as to the item proposed.

The contractor shall submit samples of all fixtures, trim and accessories when asked to do so by the engineer. The contractor shall not charge the employer with the cost of such samples nor shall he use any different from the approved sample.

PART 3 - EXECUTION

3.1 CIVIL WORK

The contractor shall execute all civil work connected with and necessary for the completion of the plumbing systems including but not necessarily limited to that described below.

3.2 SCAFFOLDING RIGGING & HOISTING

The contractor shall provide all scaffolding, rigging, hoisting and all similar services for the erection of the systems and for delivery into the premises and up to roofs where necessary of all equipment and material provided.

3.3 EQUIPMENT BASES & SUPPORTS

The contractor shall provide all structural steel and reinforced concrete bases and supports for equipment as described and/or as detailed on the drawings, including all form work cement, sand. Aggregate, reinforcing steel and structural steel such as angles, channels, "1" beams etc.

The quality of materials used shall conform to the specifications given under the applicable division of the specification.

Shop drawings of equipment bases and supports with dimensions, arrangement and size of reinforcement and size and location of anchor bolts shall be submitted to the engineer for approval before construction or fabrication.

Certified manufacturers, drawings, templates and installation instructions shall be furnished for all equipment showing operation weights, weight distribution, location of any vibration isolation mounts, size and location of anchor bolts, drains and other required openings and all other pertinent data to assist in the design of bases and supports.

Reinforced concrete bases and supports shall be adequately reinforced to carry the weight of equipment without cracking due to vibration and/or temperature stresses.

Bases and supports shall be leveled and of height and dimensions to suit the equipment. They shall extend 20cm beyond equipment edges in all directions and shall have their top edge chamfered.

Anchor bolts shall be set in oversized sleeves with washers and nuts at the bottom. Bolts shall be of a height above finished concrete to suit the equipment and to project at least 6mm above the nuts making allowance for possible required shimming under the equipment.

Anchor bolts and embedded vibration isolation shall be held in position during concrete pouring to avoid displacement.

Concrete foundations and supports shall be plastered and painted or finished as the adjacent and surrounding flooring to present a pleasing and neat appearance.

Foundations for rotating or reciprocating equipment or ground level shall be carried down independently to solid ground or rock and isolated from the floor slab with a layer of 5cm thick cork board and a mastic filler to prevent the transmission of vibrations to the building.

Equipment on intermediate floors or the roof where its foundation cannot be independently isolated from the structure shall be mounted on its support on special vibration isolators or the support shall include a substantial layer of corkboard.

Between it and the structure to reduce the transmission of vibrations to the absolute minimum.

Suspended cradles and wall brackets shall be tested to sustain a load of eight times the actual operating weight of the equipment that they support.

In mounting equipment on bases and supports the equipment shall be aligned and leveled throughout its entire length and width and where necessary suitable shims shall be provided to facilitate leveling.

Vibration isolation mounts shall be positioned in accordance with weight distribution of equipment and in a manner as recommended by the manufacturer of the equipment or of the vibration.

3.4 FIXING OF HANGERS & SUPPORTS

The contractor shall do all drilling in the building construction and shall provide all fasteners for the fixing pipe hangers and supports to the ceilings and walls.

Fasteners shall be power driven masonry expansion bolts with steel threaded studs or internally threaded studs and couplings as required.

Fasteners shall be installed in accordance with manufacturer's instructions; fasteners driven into concrete shall penetrate a distance equal to 6 to 8 times the diameter of the shank.

Fasteners in ceiling and walls shall be tested to sustain a load of 8 times the supported weight of piping or other supported equipment.

Where building construction is inadequate to provide suitable support additional framing shall be provided of a design subject to the approval of the engineer.

3.5 CUTTING & PATCHING

The contractor shall provide all cutting and patching of walls and slabs for the passage of pipes pipe sleeves, conduits etc. Patching shall match adjacent surfaces.

No structural members shall be cut without the written approval of the engineer and all such cutting if permitted shall be done as directed by him.

3.6 SLEEVES & PLATES

Sleeves shall be provided for all pipes passing through floors, walls or roofs. The contractor shall provide and locate all required sleeves before the floors, walls or roofs are built or he shall be responsible for the installation of the sleeves where these have not be installed or where incorrectly located.

Sleeves shall be securely fastened in floors and walls so that they will not be displaced when concrete is poured or when construction is build around them. Sleeves shall be plugged during construction to prevent concrete, plaster or other materials from entering.

Sleeves shall be of galvanized steel pipe. Sleeves for bare pipes shall be two nominal pipe sizes larger than the pipe passing through. Sleeves for insulated pipes shall be of sufficient diameter to pass the insulation of the specified thickness through.

The floor and wall construction finishes shall be checked to determine the proper length of sleeves for various locations to suit the following. Sleeves shall terminate flush with finished walls and ceilings, shall project 2cm above finished floors and shall project 20cm above the rough concrete of the roof.

Escutcheon plates shall be provided for all exposed uninstalled pipes passing through walls, floors and ceilings. Plates shall be nickel plated of the split ring type and size to match the pipe. Plates for pipes passing through sleeves, which extend above floor surfaces, shall be of the deep recessed type to conceal the sleeves.

3.7 WATERPROOFING

The contractor shall provide all necessary sleeves, caulking, caulking fittings and flashing to make openings in outside, walls, walls below grade and roofs absolutely water-tight, where any work pierces waterproofed construction the method of installation shall be subject to review and approval of the engineer before work is started.

Openings in exterior walls particularly at or below grade and roofs shall be kept properly plugged and caulked as all times except when being worked on to preclude the possibility of flooding due to storms or other causes.

After completion of work all openings through exterior walls below grade and through roofs shall be sealed and caulked with oakum and lead between pipe and sleeve as detailed on the drawings. For pipes passing through roofs the opening shall be further protected against the entrance of rain by means of 2mm thick lead sheet flashing secured to the pipe with special flashing sleeve and extended under the roof waterproofing membrane for a distance of 30cm all around as detailed on the drawings.

Flashing sleeves shall be coated cast iron, caulking type, as manufactured by Zum, no. z-196, or Josam, no. 1840 or approved equal. Flashing sleeves shall be supplied specifically for the pipe size concerned.

3.8 TESTING, BALANCING & ADJUSTING

A. GENERAL REQUIREMENTS

The contractor shall perform all tests and shall balance and adjust all systems as described hereunder including but not necessarily limited to the following:

- Testing of drainage and vent pipe systems to ensure their tightness.
- Hydrostatic testing of water piping systems to ensure their rightness under the prescribed test pressures.
- Testing of equipment for performance to demonstrate conformity with design requirements and proper functioning.
- Testing and adjustment of controls to verify that they operate satisfactorily as intended.
- Additional tests as may be directed by the engineer.

No part of any piping system shall be painted, covered or enclosed until it has been tested, inspected and accepted.

All tests shall be conducted in the presence of the engineer, as directed by him and his entire satisfaction.

The contractor shall provide all labor, equipment, material, instruments, power and connections required to execute all testing, balancing and adjusting as directed.

All expenses incurred by the testing shall be borne by the contractor. Such cost shall includes the cost of repair or replacement of defective work, cost of restoring, repairing or replacing damaged work resulting from the tests and the cost of replacing defective or inadequate equipment and material all as directed by the engineer.

B. HYDROSTATIC TESTING OF WATER PIPING SYSTEMS

All water piping systems shall be hydrostatically tested for ensuring complete tightness under the test pressure and for the duration of time as specified under the respective plumbing system concerned.

Systems may be tested as a whole or in sections to facilitate the progress of the work.

No part of any piping system shall be tested to a pressure less than the specified test pressure measured at the highest point of the system.

Care shall be taken not to subject any equipment, apparatus or device to a pressure exceeding its prescribed pressure as obtained from its nameplate data or from manufacturer's published data. Pressure tests shall be applied before connecting piping to equipment. Relief valves, instruments, automatic air vents and all devices that might be damaged by the test pressure shall be removed, disconnected or blanked off.

No pressure shall be applied against the closed gate or globe valves. All valves shall be in the open position but not completely back seated during testing. End valves shall be capped.

In testing flanged piping, temporary blank flanges shall be installed and firmly anchored to accommodate all developed ends thrust.

All piping that can be damaged by end thrust developing from hydrostatic testing shall be properly anchored during testing especially at changes of direction.

The piping system to be tested shall be closed by plugging and blanking all opening in the system and filled slowly with water making sure to vent all entrapped air. Plugs shall be released temporarily ensure that water has reached all parts of the system.

Pressure shall be applied to the system by means of a hand pump drawing from a water container. The pump discharge shall be connected to the system through a gauge of suitable range to have the test pressure read in the middle of the range.

After the test pressure is reached. The pump shall be blocked off by closing the globe valve and the variations of pressure in the system monitored on the pressure gauge.

The test pressure shall be maintained on the system for 24 hours during which time the system shall have no noticeable drop in pressure.

While the system is under pressure, a careful inspection shall be made all pipes and joints and if any leaks in joints or evidence of defective pipe or fitting is discovered the defective work shall be corrected immediately by replacing defective parts with new joints and materials. No make shift repairs or application of any repair compound will be permitted.

After the correction is made pressure test shall be repeated until a completely tight system is ensured.

The test pressure shall be released slowly so as not to produce shocks and sudden contractions that might damage the piping.

C. TESTING OF DRAINAGE & VENT PIPE SYSTEM

Before the sanitary fixtures are installed, drainage and vent pipe systems shall be subjected to a water pressure test to ensure and prove their tightness and to a flow test

to ensure their freedom, from obstructions.

The water pressure test shall be applied to system in the entirety or in sections. All openings in the piping shall be rightly closed with special cast iron plugs or other suitable means and the system filled with water to the point of overflow from the highest opening. The plugs are temporarily opened to make sure that all air has been vented and that water has reached all parts of the system.

No section shall be tested to less than a 3 meters headwater.

In testing successive sections at least the upper 3 meters of the next preceding section shall be tested so that no joint or pipe, except the upper 3 meters of the whole system shall have been subjected to a test of less than a 3 meters head of water.

The water shall be kept in the system or in the portion under test for at least 4 hours before inspection starts. While the system is under pressure, a careful inspection shall be made of all pipes and joints and if any leaks in joints or evidence of defective pipe or fitting is discovered the defective work shall be corrected immediately by replacing defective parts with new joints and materials. No make shift repairs or application of any repair compound will be permitted.

After the correction is made the pressure test shall be repeated until the system is proved tight.

Underground drainage pipes shall be tested by plugging the end of the pipe and filling with water to a minimum head of 3 meters. The test pressure shall be maintained for 24 hours.

Pipes and joints shall be inspected and approved before backfilling the trench.

The drainage systems shall be tested for proper flow to ensure their freedom from any obstruction. The contractor shall disassemble, clear, repair and reassemble obstructed piping at his own expense. After reassemble the piping shall again be subjected to the pressure test.

3.9 CLEANING

All work shall be brushed and cleaned before painting, concealing and accepting. Cleaning shall be performed in stages and as directed by the engineer.

All equipment, material, piping etc. shall be cleaned from the inside and outside from loose mill scale, blisters, sand, plaster, paint droppings, dirt, oil, grease, labels and any foreign matter. Piping shall be thoroughly cleaned on the outside by wire brushing before painting or covering.

After completing each section of a piping system the pipe, fittings, valves and accessories shall be cleaned internally by flashing with clean water for water systems.

3.10 PAINTING

All equipment provided shall have a factory applied finish coat of enamel paint.

Equipment surfaces that are damaged in shipment or on site and that have rusted or

corroded in storage or in place shall be restored to their original condition by cleaning and painting as directed by the engineer.

All unfinished surfaces shall be painted as directed by the engineer to present a clean and pleasing appearance.

All black steel pipes and fittings including flanges, bolts, cast iron valves and accessories, valve wheels, etc. shall be painted with two coats of zinc chromate primer irrespective of whether they will or will not be insulated. Bare black steel pipes fittings and cast iron accessories exposed to view shall be further painted with two coats of oil paint of color as directed by the engineer.

All steel and iron work such as hangers, supports, clamps, rods, bolts and nuts etc. shall be painted with two coats of zinc chromate primer and where exposed to view with two additional coats of oil paint of color as directed by the engineer.

All black steel piping run in trenches, shafts, exposed on roofs, underground or embedded in concrete or in other fill, including flanges, supports, clamps, bolts, valves and all iron and steel parts shall be painted with two coats of zinc chromate primer and two coats of heavy bituminous solution paint.

Paint shall not be applied except on clean, dry surfaces. Surfaces to be painted shall be cleaned of all rust, loose mill scale, oil grease and dirt by wire brushing and the use of a cleaning solution.

Before any steel or ironwork is painted all voids and irregularities shall be filled with a suitable and approved compound.

All paint used shall be of the best grade and specially suited for the application. Paint to be used on hot surfaces shall be of the heat resistant type.

Paint shall be delivered to the site in the original sealed containers and shall be applied in accordance with the manufacturer's instructions. The paint shall be evenly spread and well brushed out to avoid drops, runs or sags.

3.11 EXCAVATION & BACKFILL

The contractor shall perform all excavation and backfill necessary for the excavation or the plumbing systems such as the installation of underground piping, the construction of underground structures, etc. including all necessary shoring, bracing, pumping, restoring and protection for safety of persons and property.

Pipe laying work shall be conducted so that trenching operations are not too far advanced ahead of pipe laying operations to avoid excessive length of open trench. The contractor shall be responsible for installing guards for the protection of persons.

When required the contractor shall provide supports of sheet-pile adequately braced and supported or other adequate shoring for the prevention of bank cave-ins. Excavation shall be kept free of water at all times with attended pumping equipment.

Trenches for underground pipes shall be of adequate width and depth. Excavation shall be carried down to 20cm below the bottom of pipe.

The bottom of the trench shall be bedded with clean dry sand and trimmed by hand to receive the pipes at their respective finished levels and grade. Pipes shall be laid at the required uniform slopes and shall be supported along their whole length with packed sand that shall cover at least one-third of the circumference of the pipe. A bell hole of adequate size shall be dug at each joint for properly making up the joints.

Immediately after piping is installed, inspected, tested and accepted the trench shall be carefully backfilled with selected material of clean earth that shall be free of stones, slag, ashes, vegetable or organic materials, building or other debris, refuse or other material that could damage the pipes or cause corrosion action.

The backfill shall be carefully deposited in 10cm layers up to 60cm above the pipe and 30cm layers for the remaining depth, thoroughly and carefully tamping each layer before placing the next layer. Great care shall be exercised during the backfilling operation not to cause injury or misalignment to the pipes.

Where rock is encountered excavation shall conform to the applicable provisions of the specification.

The contractor shall remove surplus and unsuitable excavated materials from the site as directed.

The contractor shall restore surfaces, sidewalks, pavements, curbing, lawns and shrubs disturbed or damaged by the excavation work.

3.12 EXTERNAL DRAINAGE PIPES

Pipe connections to manholes, city sewers or any other underground structure shall be made in a completely watertight and approved manner.

Pipe connections to existing systems shall be made with minimum disturbance to the existing lines.

Any existing pipes or structures, which are damaged, while making connections to them shall be replaced or reconstructed to the satisfaction of the engineer and without any cost to the employer.

Pipes shall be kept clean until final acceptance of the work. Exposed ends of all incomplete lines shall be closed with wooden plugs and adequately secured at all times when pipe laying is not actually in progress.

Pipes shall be installed on a good foundation and adequate means taken to prevent settlement. Pipes laid in trenches shall be provided with a solid uniform bearing throughout their entire length.

Pipes shall not be buried at less than 60cm below finished grade for protection against

mechanical damage. Pipe shall not be run closer than 1m to building bearing walls and footings for protection against building settlement.

All pipes shall be laid to a uniform slope as shown on the drawings. Slopes shall be limited to 3% maximum. The free vertical drop of a sewer pipe into a new or an existing manhole shall be limited to 45cm between the invert level of the pipe opening and the bottom of the manhole. Where conditions necessitate that the drop would exceed 45cm at the maximum slope of 3% a drop manhole shall be used, of detail as shown on the drawings.

Trenches shall be kept free of water by pumping, use of well points, under drains or other approved means during pipe laying operation so that all pipe joints are made in the dry.

Precautions shall be taken to protect incomplete work from floating due to storms or from any other cause. All pipelines or structures not stable against uplift during construction shall be well braced or otherwise protected.

All completed underground lines shall be subject to the inspection and approval of the engineer. All pipes shall be true to line and grade. The full circle of the pipe shall be visible at the manholes. All joints shall be inspected for tightness as described under Testing, Balancing and Adjusting.

If any structure, pipe or joint is found defective, the contractor shall repair or replace all defective work as directed by the engineer.

PART 4 - MEASUREMENT AND PAYMENT

4.1 DESIGN CRITERIA, GENERAL REQUIREMENTS AND OTHER

NOTES: Those clauses are intended as a guide only to the method adopted in the preparation of the Bill of Quantities and the measurement of the Works. Contractors must note that rates for items must include everything necessary for the proper execution of each item and that all ancillary work is included unless specifically otherwise stated measured.

4.2 All items are measured net as fixed in position

4.3 Rates must include work at all levels. Furnishing and installation, and testing where applicable . Each item includes also, unless otherwise specifically stated, all labors in making and all costs in connection therewith, materials, goods and all costs in connection therewith (e.g conveyance, delivery, unloading, storing, unpacking, returning packing, handling, hoisting, lowering and the like), fitting setting and fixing materials and goods in position, all square raking and curved cutting, waste of and laps in materials, use of plant, temporary works, patterns, models, templates, method statements , samples, establishment, calculation sheets, shop drawings, reports, as built Drawings, & overhead charges and profit.

4.4 Quantities are billed to the nearest whole unit. Fractions of a unit less than half are

disregarded and all other fractions are regarded as whole units.

- 4.5** All quantities are quoted in metric units of measurement.
- 4.6** All rates shall be quoted in Egyptian Currency.
- 4.7** Attention is also directed to the specifications, BOQ, and drawings which contain further notes on all work required and which are deemed to be included in rates quoted in attached Bills of Quantities.
- 4.8** Attention is also directed to pricing all items which having quantities ignoring items having no quantities. Otherwise The Tender is judged to be unbalanced , it may not be accepted as a responsive Tender and these rates wouldn't take into consideration
- 4.9** Balanced distribution of the Tender price by the Tenderer is expected among the various bill of quantity (BOQ) Items. An unbalanced Tender is one offering unreasonably low prices on one or more BOQ items and compensating for them with unreasonably high prices on other BOQ items prices quoted on the BOO for items to be supplied and/or constructed early must not be unduly high while other unduly low prices are quoted for BOQ items to be completed during the later stages of the work. Tenderers are advised that if, in the opinion of the Employer, The Tender is judged to be unbalanced it may not be accepted as a responsive.

PART 5 DIVISIONS OF WORKS

5.1 SITE WATER NETWORK:

- a. Water pipes shall be measured in linear meter including excavation in all types of soil to the required level, strutting of sides, dewatering if necessary, and bedding under and above pipes, installation, testing and backfill. The Unit also includes supply and installation of pipes complete with the fittings (Tees-bends-reducers-thrust blocks-etc.) all as specified and shown on the drawings.
- b. Valves and hydrants shall be measured per unit, including all joints, flanges, accessories, as specified and shown on drawings.

5.2 SITE SEWAGE NETWORK

- A. GRAVITY SEWERS PIPES:** shall be measured in linear meter from the outer wall dimension of a manhole to the outer wall dimension of the next manhole. The work includes excavation in all types of soil to the required level, strutting of sides, dewatering if necessary, and bedding under and above sewer lines, installation, testing and backfill. The unit also includes supply and install of popes and jointing, all as specified and shown on the drawings.
- B. MANHOLES:** Manholes shall be measured per lump sum, the work includes excavation to the required level in all types of soil, dewatering if necessary, all concrete work, manhole frame and cover, all complete as shown on drawings.

5.3 COLD AND HOT WATER PIPING INSIDE BUILDINGS

- A. COLD AND HOT WATER PIPING:** shall be measured by linear meter, complete with fittings, the unit price includes fixing of pipes, hangers, supports when includes excavation and backfill when installed underground.
- B. VALVES:** Shall be measured by unit including all necessary accessories for jointing with pipes.

5.4 SANITARY FIXTURES

- A. Any sanitary fixture such as (WC, Lavatory, bath tub, shower tray sink,.etc) shall be measured per Lump sum. The rate includes the supply, installation, testing, and following:

- 1- Soil, waste and vent piping from the sanitary fixture up to the soil, waste and vent stacks.
- 2- The cold, hot water supply vertical branch piping to the sanitary fixture from the horizontal water piping in the toilet area which is measured individually per linear meter.

5.5 SOIL, WASTE AND VENT STACKS

- A. The soil, waste and vent stacks shall be measured in linear meter, including supply of pipes, fittings with rubber gaskets, installation, supports and hangers and testing .

End of Section

SECTION 02210
EXCAVATION, TRENCHING AND BACKFILL

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK :

THE CONTRACTOR SHALL, UNLESS INFORMED OTHERWISE :

1.1.1 Carry out a land survey and site investigation of the route of each pipeline.

1.1.2 Check tender drawings and modify the pipeline profile and redesign the associated ancillary works as necessary .

1.1.3 SET OUT THE WORKS :

Clear and grade the pipeline route including all temporary works of any kind, breaking up, protection or diversion of service.

1.2 APPLICABLE TESTING :

Testing of materials	ASTM D 422
Sieve Analysis	ASTM D 2217
Moisture Content	ASTM D 2216
Moisture Density	ASTM D 1557
Density in-place (Sand Cone Method)	ASTM D 1556
Density inplace (Drive Cylinder Method)	ASTM D 2937
Density in place (Rubber Balon Method)	ASTM D 2167
Maximum Index Density	ASTM D 4253
Minimum Index Density	ASTM D 4254

1.3 SCOPE OF WORK :

1.3.1 WORK INCLUDED :

Work to be done under this Section includes, but is not limited to, the following items including all labor, materials, equipment and services necessary and incidental to the proper execution of the Work as shown on the Drawings and as specified herein.

- a-** Clearing grubbing and site preparation as required.
- b-** Excavation all types of materials to limits indicated or required, including soil, rock, utilities, pavements, curbs and other materials and obstructions for new below-grade construction, and other site improvements indicated on the Drawings.
- c-** Retrenching, as required, to remove or work around potential obstructions which might affect installation of excavation support systems.
- d-** Designing, furnishing, installing and maintaining temporary support systems for excavations required for construction of the Work indicated on the Drawings and

specified herein and for excavations required for utility relocations. The excavation support system shall be designed by the Contractor and reviewed by the Engineer.

- e- Excavating trenches for utility relocations and appurtenant structures whether indicated on the Drawings or not.
- f- Handling and legally disposing of excavated materials as specified .
- g- Preparing subgrades to the limits indicated on the Drawings and as specified.
- h- Providing specified materials from off-site source as required.
- i- Backfilling and compaction operations associated with Common Fill, Select Common Fill, Screened Gravel, structural Fill, Gravel Base Course and Riprap Placement; new utility construction; utility relocation work; sidewalk and pavement reconstruction ; and other areas where backfill is required for project construction.
- j- Grading, shaping and compacting excavation subgrades, backfills, and original ground upon which pavement, surfacing, base, sub-base or structures are to be placed.
- k- Restoring grade to original conditions beyond site limits where disturbed.
- l- Coordinating the Work specified in this Section with groundwater control specified in Section 02245.

1.4 RELATED WORK NOT INCLUDED :

1.4.1 Geotechnical instrumentation and monitoring is included in Section 02015.

1.4.2 Groundwater control is included in Section 02245.

1.4.3 Water system is included in Section 02715.

1.4.4 Storm drainage system is included in Section 02725.

1.4.5 Sewerage system is included in Section 02735.

1.4.6 Concrete manholes are included in Section 02601.

1.4.7 Inspection Chambers are included in Section 02190.

1.4.8 Polyvinyl Chloride pipe (P.V.C) is included in Section 02622

1.4.9 Reinforced concrete pipe is included in Section, 02612.

1.4.10 Glass reinforced plastic (G.R.P) is included in Section 02609.

1.4.11 Ductile Iron pipe is included in Section 02616.

1.4.12 Steel pipe is included in section 02617.

1.4.13 Concrete is included in Division 3.

1.5 SUBMITTALS :

1.5.1 Submittals shall be made of two stages. Items to be included in the First (Preliminary) Stage and the Second (Final design) Stage are described in the following paragraphs. A preconstruction meeting between the Engineer and the Contractor shall be held to discuss the First Stage submittal following the Engineer's review and prior to submission of the Second Stage submittal.

1.5.2 The submittals required herein should be coordinated with submittals required under section 02245 . Groundwater Control . The preconstruction meeting will be held to discuss the submittals required under these sections.

1.5.3 First stage Submittal - submit the following within two weeks after Notice to proceed:

- a- A brief description of existing site conditions and soil and groundwater conditions anticipated for various portions of the work. Include distances along the alignment, generalize subsurface profiles and a summary of the data used as the basis for the expected conditions.
- b- A description of the excavation support systems which are proposed along the trench alignments. Provide a plan of the alignments indicating which methods are proposed based on anticipated conditions along the route.

1.5.4 Second stage submittal - submit shop drawings of excavation support system (s) Showing layout and sizes of all system components. After the preconstruction meeting and at least three (3) weeks prior to installation of each proposed system.

1.5.5 SUBMIT THE FOLLOWING AT LEAST TWO (2) WEEKS PRIOR TO USE :

- Results of laboratory grain size analyses and compaction tests for each type of material to be utilized as fill or backfill. The use of a material will not be allowed before laboratory test results have been received by the Engineer and the material has been judged as acceptable by the Engineer.

1.6 QUALITY ASSURANCE :

1.6.1 Conduct routine inspection of all structural elements subject to reuse to determine whether they comply with the excavation support design.

1.6.2 Testing and Monitoring : In-place soil compacting tests shall be performed by a testing laboratory employed by and at the expense of the Contractor .

METHODS OF TESTING : THE FOLLOWING TESTS WILL BE REQUIRED:

- a- Gradation tests shall be in accordance with ASTM D422 and ASTM D2217. One test for each fill type per 500 m3 of fill will be required for each location where backfill is in progress, plus one additional gradation test each week from each source.

- b-** Maximum density and optimum moisture content determination for Common Fill and Select Common Fill shall be in accordance with ASTM D698 and for Structural Fill shall be in accordance with. ASTM D1557 Two initial tests will be required for each type or fill or backfill material from each source proposed, then one test per every 500 m³ of fill for each location where backfill is in progress.
- c-** For area fills, an in-place field density test for each 300 m³ of material placed. For pipelines, in-place field density tests shall be performed at average intervals of 100 meters along the trench for each lift of fill. The tests shall be carried out according to ASTM D1556 with the following additions :
 - 1-The sand shall pass a 0.6 mm sieve and be retained on a 0.3 mm sieve.
 - 2-in no case shall the test hole be less than 150 mm deep and in the case of structural Fill it must fully penetrate the layer being tested.
 - 3-the diameter of the test hole shall be less than 100 mm.

1.6.3 TOLERANCES :

- a-** Construct finished soil and backfill surfaces to plus or minus 12 mm of the elevations indicated.
- b-** Maintain the moisture content of fill material as it is being placed within plus or minus two percent of the optimum moisture content of the material as determined by the laboratory tests specified herein.

1.6.4 Provide the Engineer with a 25 Kg sample of all on-site and off-site material proposed and the source of the material.

1.6.5 Reviews and Acceptance : No earthwork material will be accepted on the jobsite unless indicated in writing by the Engineer.

1.6.6 Materials conforming to the requirements of paragraph 2.02 which are placed and compacted to less than the specified density shall alternatively be :-

- a.** Recomacted as required to achieve the specified density.
- b.** Removed and replaced with properly placed and acceptable compacted material.

1.6.7 Materials placed and/or compacted which do not conform to project specifications for the area shall be removed and replaced with suitable material when directed by the Engineer at no additional cost to the Employer.

1.6.8 The Contractor shall be responsible for making prompt and continuous evaluations of monitoring data and excavation support system performance and, whenever necessary, taking immediate steps to correct any deficiencies in the capacities or stiffness of individual members or to provide other corrective measures which may be required to prevent damage or excessive movements.

1.7 PROTECTION :

1.7.1 GENERAL :

The Contractor has sole responsibility for preventing damage to adjacent structures and other work, and for job safety during execution of the work . Excavation support systems where required, shall be designed to support the sides of excavations such that damage to adjacent structures by undermining or excessive ground movements outside the excavation is prevented. The contractor's attention is directed by the Engineer CARE AND PROTECTION OF PROPERTY.

1.7.2 OPEN CUTS :

Trench sides may be sloped or battered only in those areas where the increased trench width will not interfere with existing surface features or the limits of permanent rights-of-way. Trench sides shall be of sufficient slope to prevent caving or sliding. Slopes shall not extend lower than the limits shown on the Drawings. Use of sloped or battered trench sides is subject to acceptance of the Engineer.

1.7.3 SHEETING AND BRACING :

- a- Furnish, put in place, and maintain such sheeting and bracing as may be required to support the sides of excavations, to prevent any movement which could in any way diminish the width of the excavation below that necessary for proper construction, and to protect adjacent structures from undermining or other damage.
- b- Where sheeting and bracing are required to support the sides of excavations for structures, the Contractor shall engage a qualified engineer to design the sheeting and bracing . The Contractor shall submit the qualifications of the Contractor's sheeting and bracing design engineer for review by the Engineer prior to designing the system. The sheeting and bracing installed shall be in conformity with the design, and certification of this shall be provided by the sheeting and bracing design engineer.
- c- Sheeting and bracing design shall account for all soil and water pressures and surcharges from traffic, adjacent structures, material stockpiles, construction equipment or any other loads which will be imposed on the system at any stage of excavation and bracing and construction of the Work.
- d- Design the sheeting and bracing system for staged removal of bracing in accordance with the sequence of concrete placement and backfilling.

1.8 EXCAVATION RESTRICTIONS :

1.8.1 Access for pedestrians shall be maintained to structures adjacent to the Work at all time during construction.

1.8.2 Utilities servicing structures adjacent to the Work shall be maintained at all times during construction.

- 1.8.3** excavation shall proceed " in-the -dry". Control surface water and groundwater as specified in Section 02200, Groundwater Control.

PART 2 - PRODUCTS

2.1 MATERIALS FOR EXCAVATION SUPPORT :

2.1.1 STEEL SHEET PILES :

A continuous interlocking type, ASTM A328 standard grade, non-damaged, with cross-sections selected for intended use.

- 2.1.2** Soldier piles and Bracing: Structural Steel for use as soldier piles and in bracking systems shall conform to the current edition of "AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings".

- 2.1.3** Timber structural grade having a minimum allowable working stress of 1100 psi. Basis for determination of minimum allowable working stress shall be ASTM D2555 and ASTM D245.

2.1.4 WELDING :

Welding shall conform to American Welding Society Code D1.0-69 for Welding in Building Construction.

2.2 EARTH MATERIALS :

2.2.1 COMMON FILL :

Common Fill shall consist of mineral soil substantially free from organic materials, loam, wood, trash and other objectionable materials which may be compressible or which cannot be properly compacted. Common Fill shall not contain stones larger than 150 mm in largest dimension and shall be well graded. Common Fill shall not contain stone blocks, broken concrete, masonry rubble or other similar materials. It shall have physical properties such that it can be readily spread and compacted during filling.

2.2.2 SELECT COMMON FILL :

Select Common Fill shall be as specified above for Common Fill except that the material used shall contain no stones larger than 50 mm largest dimension.

2.2.3 CRUSHED STONE :

- a-** Crushed stone shall be used for pipe bedding as detailed and at other locations indicated on the Drawings.
- b-** Crushed Stone shall consist of hard, durable rock particles (crushed limestone will not be allowed) of proper size and gradation, and shall be free allowed) of proper size and gradation, and shall be free from sand, loam, Clay, excess fines, and deleterious materials. Crushed Stone shall be capable of being spread to

easily fill voids and shall be capable of being compacted with little effort. Crushed Stone shall be graded within the following limits :

For pipe Bedding :

Sieve	Percent Passing
16 mm	100
13 mm	40 – 100
10 mm	15 - 45
No. 10	0 - 5

2.2.4 STRUCTURAL FILL :

- a- Structural Fill shall be clean and free from loam, rubbish, wood, trash or other objectionable materials which cannot be properly compacted. Structural Fill shall be graded within the following limits :-

Sieve Size	Percent Passing
10 mm	100
No. 4	95 - 100
No. 8	80 - 100
No. 16	50 - 85
No. 30	25 - 60
No. 50	10 - 30
No. 100	2 - 10

- b- Where Structural Fill is used it shall be placed in 200 mm thick lifts with each lift compacted to at least 95 percent of maximum dry density as determined by ASTM D1557, unless directed otherwise by the Engineer.

2.2.5 RIPRAP :

The material shall have a minimum dimension of 150 mm and a maximum dimension not greater than the specified lift thickness. It should be of sound, durable rock which is angular in shape and of suitable quality to ensure performance in the condition in which it is angular in shape and of suitable quality to ensure performance in the condition in which it is to be used, rounded boulders, sandstone or similar soft stone or relatively thin slabs will not be acceptable . Material shall be free from overburden, spoil, shale, and organic material, and be subject to the Engineer's acceptance, Riprap used in irrigation canal and open drain linings shall conform to the above requirements.

2.2.6 GRAVEL BASE COURSES :

- a- Materials for gravel base course shall consist of 150 mm maximum size gravel, sandy gravel, or gravely sand free of organic material, loam, wood, trash, and other objectionable material, and shall be graded within the following limits :

Sieve Size	Percent Passing
150 mm	100
13 mm	50 - 85
No. 4	40 - 75
No. 40	10 - 35
No. 200	0 - 10

- b- Additionally, material placed within 150 mm of finished base coarse surface shall not contain stones larger than 50 mm in any dimension.

PART 3 - EXECUTION

3.1 PREPARATION :

3.1.1 Ground surface within the construction areas of the working site shall be cleared of all brush, debris, and surface vegetation. Stumps and roots larger than 50 mm in diameter shall be completely grubbed and removed . Matted roots shall be removed regardless of size. Surface vegetation shall be removed complete with roots to a depth of not less than 100 mm below the ground surface.

3.1.2 All areas and all trees or group of trees or designated by the Engineer to remain, shall be protected from damage by all construction operations. Should additional trees or groups of trees have to be removed to carry out the Work, obtain permission from the proper authorities or owners and acceptance of the Engineer.

Clearing operations shall be conducted in a manner to prevent falling trees from damaging trees designed to remain. Protection of trees designated to be preserved shall include barrier or fence protection, trimming of trees and preventing stockpiled material from covering tree trunks.

All combustible and other waste materials resulting from construction operations shall be removed within the limits shown and disposed of by and at the expense of the Contractor. Open burning is not permitted.

3.1.3 Remove and stockpile all topsoil within a minimum depth of 100 mm from surfaces to be excavated, from fills, and from any other areas on the site on the site of the Work where the original ground surface will be covered or damaged. After all other work has been completed in each area, topsoil shall be placed and graded to the satisfaction of the Engineer.

3.2 SHEETING AND BRACING :

3.2.1 Construct the sheeting outside the neat lines of the foundation unless indicated otherwise to the extent deemed desirable for the method of operation. Sheeting shall be plumb and securely braced and tied in position. Sheeting and bracing shall be adequate to withstand all pressures to which the structure or trench will subjected. Any movement or bulging which may occur shall be corrected so as to provide the necessary clearance and dimensions.

3.2.2 Care shall be taken to prevent voids outside of the sheeting, but if voids are formed, they shall be immediately filled and rammed . Where soil cannot be properly compacted to fill a void, lean concrete (175 Kg/m³ cement content) shall be used as backfill at no additional expense to the Employer.

3.2.3 For purposes of preventing damage to structures, utilities or property whether public or private, leave in place and embed in the backfill all sheeting and bracking where indicated on the Drawings or directed by the Engineer in Writing. The Engineer may direct that sheeting and bracing be cut off at any specified elevation. Sheeting directed by the Engineer to be left in place shall be paid for at the unit rates listed in the Bill of Quantities.

3.2.4 The right of the Engineer to order sheeting and bracing left in place shall not be construed as creating any obligation on his part to issue such orders, and his failure to exercise his right to do so shall not relieve the Contractor from liability for injury to persons or damage to property occurring from or upon the work occasioned by negligence or otherwise, growing out of a failure on the part of the Contractor to leave in place sufficient sheeting and bracing to prevent any caving or moving of the ground.

3.2.5 All timber sheeting installed to below the spring line of an adjacent pipe shall be cut off and left in place below the level 300 mm above the pipe crown. If site conditions allow, timber sheeting driven below the spring line of a pipe and above the trench bottom may be removed as coordinated and approved by the Engineer.

3.2.6 All sheeting and bracing not left in place shall be carefully removed as the backfilling proceeds in such manner as not to endanger the construction or other structures, utilities, or property. All voids left or caused by withdrawal of sheeting shall be immediately refilled with sand by ramming with tools especially adapted to that purpose, or otherwise as may be directed.

3.3 EXCAVATION BELOW DESIGNATED TRENCH BOTTOM :

3.3.1 If the Contractor excavates below designated trench bottom through error or for his own convenience, or fails to properly control groundwater in the trench, or disturbs the subgrade by his construction operations or equipment, or otherwise fails or neglects to conduct the excavation work so that the surface of the subgrade is in proper condition for construction, he shall remove all unsuitable materials and replace them with Class 20 concrete or structural Fill at his own expense so that the condition of the subgrade is acceptable to the Engineer before any work is placed thereon.

3.3.2 If, in the opinion of the Engineer, the material, in its undisturbed natural condition, at or below the normal subgrade of the excavation as indicated on the Drawings is unsuitable for foundations, it shall be removed to such depth and width as directed and be replaced with structural Fill or other suitable material as directed by the Engineer. Removal and replacement of unsuitable material when directed by the Engineer will be paid for under the provisional Sum.

3.4 TRENCH EXCAVATION AND BACKFILLING :

- 3.4.1** Excavation for all trenches required for the installation of pipes, ducts and cables shall be made to the elevations indicated on the Drawings and in such a manner and to such widths as will give suitable room for laying the pipe or cable or installing the ducts within the trenches, for bracing and supporting, and for groundwater control systems. The bottom of all excavations shall be firm and dry and in all respects acceptable to the Engineer.
- 3.4.2** Excavation may occur in the course of former agricultural drains or canals. The former watercourses have been filled with unknown materials. Significant amounts of much and debris such as concrete rubble, old car bodies and rubbish are expected which will be unsuitable for pipe subgrade or as backfill. Remove unsuitable material from the site and dispose of it.
- 3.4.3** The trench widths at the bottom of trench to a point 300 mm above the pipe shall be limited as follows :

TRENCH WIDTHS	
PIPE SIZE	MAXIMUM TRENCH WIDTH
(mm)	(mm)
100 - 150	1000
200 - 250	1100
300	1150
375	1250
450	1300
600	1700
700	1800

Minimum trench width shall not be less than 400 mm plus the outside diameter of pipe.

- 3.4.4** If encountered, rock shall be removed to a minimum 300 mm clearance around the bottom and sides of all the pipe being laid. Rock shall be defined as previously undisplaced bedrock which extends beyond the trench width.
- 3.4.5** Excavation to final subgrades shall be made by hand or with equipment with smooth-bladed buckets for at least the final 500 mm and as necessary to prevent disturbance of subgrade soils. In locations where mechanical equipment would cause damage to trees, buildings, utilities or other existing properties, hand excavation work shall be required.
- 3.4.6** Pipe with concrete encasement or arches shall not be backfilled before three days after placing concrete for encasement or arches.
- 3.4.7** Where pipe is to be installed in Granular Bedding, the Crushed Stone shall be placed and compacted to the total depth required (rough grade elevation) and then re-excavated for pipe installation.

- 3.4.8** As soon as practicable after the pipe has been laid and jointed, backfilling shall begin and thereafter be prosecuted expeditiously. Granular Bedding, Type 1, Crushed Stone shall be placed and compacted under and around the pipe to mid-diameter as shown on the Drawings and specified in the applicable pipe sections. For Granular Bedding, Type 2, sand shall be placed and firmly compacted under and around the pipe to a depth of 300 mm over the top of the pipe as shown on the Drawings and specified in the applicable pipe sections.
- 3.4.9** For Granular Bedding, Type 1, after Crushed stone bedding has been placed to the mid-diameter of the pipe, select common fill shall be placed to a depth of 300 mm over the top of the pipe. Select common fill be carried up evenly in maximum 150 mm layers measured prior to compaction and compacted to 95 % maximum density as determined by AASHTO.
- 3.4.10** Where the pipes are laid cross country, the remainder of the trench above select common fill shall be filled with common fill in layers not to exceed 300 mm prior to compaction and compacted to at least 95 percent of maximum density as determined by AASHTO . The backfill shall be mounded 150 mm above the existing grade or as directed. Wherever a loam or gravel surface exists prior to cross county excavations, it shall be replaced to the full original depth as part of the work under the pipe items. In some areas it may be necessary to remove excess material during the clean-up process, so that the ground may be restored to its original level and conditions. If the Contractor prefers not to store loam or topsoil he shall replace it with loam or topsoil of equal quality and in equal quantity.
- 3.4.11** Where the pipes are laid in roadways, or other paved areas, the reminder of the trench above the select common fill and up to a depth of 300 mm below the bottom of the permanent reinstatement shall be backfilled with Common Fill in 200 mm layers measured prior to compaction and compacted to at least 95 percent at maximum dry density as determined by AASHTO . The 300 mm layer below the bottom of the permanent reinstatement shall be filled with road base.
- 3.4.12** At locations where the pipe crosses a water main or service connection the pipe shall be encased in concrete as indicated on the Drawings and/or as directed by the Engineer.
- 3.4.13** Special attention is called here to the need to protect water and sewer pipes that are under pressure, and especially the concrete thrust blocks along these pipelines. If the soil on which any thrust block depends for its resistance is disturbed by construction under this contract, provide the same resistance for the pipe fittings as that formerly provided by the soil before it was disturbed. Adequate measures may include, but not be limited to, the use of piles driven in the thrust block or fitting, bracing that extends from the thrust block to undisturbed soil, or installation of a larger thrust block, incorporating the existing one that extends to undisturbed soil,.

3.5 STRUCTURE EXCAVATION :

3.5.1 Excavation shall be made to the elevations shown on the Drawings and to such widths as will give suitable room for construction of the structures, for bracing and supporting for control of groundwater and drainage. The bottom of the excavations shall be firm and dry and in all respects acceptable to the Engineer.

3.5.2 Excavation shall be in the dry and shall be accomplished by methods which preserve the undisturbed state of subgrade soils.

3.5.3 Excavation equipment shall be satisfactory for carrying out the work in accordance with the Specifications. In no case shall the earth be ploughed, scraped, or dug with machinery so near to the finished subgrade as to result in excavation of, or disturbance of material below the subgrade. As necessary to prevent disturbance to the bearing soils, at least the final 500 mm of depth to subgrade shall be excavated with smooth edge buckets or by hand shovel.

3.5.4 When excavation for foundations has reached prescribed elevations, the engineer shall be notified and he will inspect conditions. If materials and conditions are not satisfactory to the Engineer, the Engineer will require remedial work.

3.6 BEDDING FOR STRUCTURES :

All excavations beneath structures and manholes in the locations and to the thickness indicated on the Drawings shall be filled with blinding concrete class 20. Blinding will be placed on undisturbed material.

3.7 MISCELLANEOUS EXCAVATION :

Perform all the remaining miscellaneous excavation . Make all excavations necessary to permit the placing of loam and plants, for constructing roadways and any other miscellaneous earth excavation required under this contract.

3.8 BACKFILLING - COMMON FILL :

3.8.1 Common fill may be used adjacent to structures beyond the limits of structural Fill, for filling in existing canals and drains, and as embankment fill, or as shown on the Drawings, or in other areas as designated by the Engineer. In open areas where large compacting equipment can be used for compaction (i.e. vibrator rollers), Common Fill shall be placed " in-the-dry" in 300 mm layers measured before compaction. In Confined areas where hand-guided compaction equipment, such as walk-behind vibrator plate compactors or hand tamping are used, lift thickness prior to compaction shall be 150 mm or less.

- 3.8.2** Common Fill shall be compacted to at least 95 percent of maximum density as determined by AASHTO compaction Tests,. Common Fill material in place shall be compacted with compaction devices acceptable to the Engineer.
- 3.8.3** Fill shall be brought up in substantially level lifts starting in the deepest portion of the fill. The entire surface of the work shall be maintained free from ruts, and in such condition that construction equipment can readily travel over any section. Fill shall not be placed against concrete structures until they have attained sufficient strength.
- 3.8.4** No Common Fill shall be placed until all organic materials, including peat and loam, and loose inorganic silt material have been completely removed from the area to be filled. Test pits may be used to determine the depth of this material.
- 3.8.5** Material placed in fill areas shall be placed to the lines and grades shown on the Drawings making due allowance for settlement of the material and for future loam placement.
- 3.8.6** The surface of filled areas shall be graded to smooth true lines, strictly conforming to grades indicated on the grading plan and no soft spots or uncompacted areas will be allowed in the work..
- 3.8.7** No compacting shall be done when the material is too wet either from rain or from excess application of water. At such times, work shall be suspended until the previously placed and new materials have dried sufficiently to permit proper compaction.

3.9 DISPOSAL OF MATERIALS :

- 3.9.1** Excavated material shall not be removed from the site of the work or disposed of except as directed or acceptable to the Engineer. Any excavated material not required for use in the work or not suitable for use as fill in the work shall be deemed to be the property of the Contractor. Removal and disposal of this material from the site shall be the responsibility of the Contractor. The Employer may specify public and private properties to receive fill but at no time will excess fill be placed on private property without the consent of the Engineer. In order to avoid unauthorized disposal, arrange that each driver employed for the disposal of such materials is given written instructions as to the acceptable place where each load is to be tipped. Retain copies of such instructions, together with a list of approved places to be used, for inspection at any time by the Engineer. The employer shall be indemnified against any claims.
- 3.9.2** Should conditions make it impractical or unsafe to stack material adjacent to the excavation, haul and store the material to a location provided by the Contractor. When required, schedule and use the material in backfilling the excavation . No additional compensation will be made for rehandling material.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

- 4.1.1 The quantities of excavation shall be measured per "cubic metre" by multiplying the area resulting from the outside dimensions of the pits or trenches, as indicated on drawings, by the depth measured from the ground level to the base of foundations indicated according to the boring done by the contractor. No allowance is to be made for bulking.
 - 4.1.2 The quantities of backfilling or filling and covering structural members in foundation pits or trenches shall be per "cubic metre" according to item (A.1) after deducting the structural members.
 - 4.1.3 Payment for rock excavation, as defined above, shall be at the agreed unit price per "Cubic Metre." Computation will be made in a vertical plane from the lowest point rock is excavated.
- 4.2 Unit prices affixed items of earth work shall include for all labour, plant, materials, equipment, tools, implements and incidentals necessary to carry out, protect and maintain earth work as shown and in accordance with this section.

End of Section

SECTION 02605 INSPECTION CHAMBERS

PART 1 - GENERAL

1.1 SCOPE WORK

- A-** Provide sewer connections to all buildings within the contract work limits as shown on the drawings.
- B-** Connect each building drain to the nearest new downstream sewer manhole using the Inspection Chambers as detailed on the drawings. Typical Inspection Chambers piping arrangements are shown on the Drawings.

1.2 RELATED WORK NOT INCLUDED

- * Earth works is included in section 02200.
- * Asbestos cement pipes is included in section 02610
- * Vitrified clay pipes is indicated in section 02621
- * Polyvinyl chloride (P.V.C) is included in Section 02622.
- * Concrete is included in Division 3.
- * Masonry is included in division 4 .

1.3 SUBMITTALS

- A-** Before the Construction of any Inspection Chamber in any street the Contractor shall submit to the Engineer a sketch showing the location of all building discharge pipes and layout of all piping from building to Inspection Chamber and from Inspection . Chamber to sewer manholes. The Contractor shall identify in his submittal schools, hospitals, clubs mosques, high-rise buildings and any other institutional, commercial or industrial establishments.

PART 2 - PRODUCTS

2.1 MATERIALS

- A-** All piping between the Inspection Chambers and street sewer manholes and between the individual Inspection Chambers shall be P.V.C piping.
- B-** Inspection Chamber shall have A top frame of concrete shall be made for fixing the cast Iron cover, the cover shall be double seal type weighting 125 Kg and with size 600 x 600 m and be dipped in hot bituminous solution.
- C-** Inspection Chambers have a plain concrete bottom. The cast-in-place bases of Inspection Chambers shall be placed as indicated on the drawings. Cast-in-place bases shall be constructed in accordance with the requirements of Section 03300.
- D-** The wall of Inspection Chambers shall be solid concrete block. This Brick only have to meet the following criteria.
- | | | |
|-----------------------|------------|------------------------|
| Min crushing strength | Average | 300 Kg/m ² |
| | Individual | 250 Kg/cm ² |
| Max. water Absorption | Average | 9 % |
| | Individual | 12 % |
- E-** The wall Inspection Chamber to be plastered with cement plaster, channels the bottom to be made of concrete.
- F-** Inspection Chambers exceeding 1.00 m in-depth shall be furnished with C.I. step Iron.
- G-** Outer surfaces of Inspection Chambers shall be given two coats of bituminous damproofing at the rate of 1 m² per liter as directed by the Engineer and in accordance with manufactures instruction.

PART 3 - EXECUTION

A- HOUSE CONNECTION PROGRAM

- 1- All building drains are to be connected to the street sewer manholes through Inspection Chambers. Any exceptions have to be approved by the Engineer. No more than two building connections can be made to any Inspection Chamber unless approved by the Engineer. Inspection Chambers shall be provided for building under construction. Street manhole stubouts shall be provided for vacant lots as directed by the engineer.

- 2- All piping between the Inspection Chamber and the street sewer manholes shall be equal to or greater than 150 diameter pipe laid at a minimum 1 percent slope. Large buildings that have 150 diameter or larger building drains shall required a larger Inspection Chamber exit pipe.

In this case the Inspection Chamber exit pipe shall be a minimum of one pipe size greater than the building drain pipe. If the Inspection Chamber outlet pipe is 150 mm diameter or greater the street sewer may have to be enlarged. Immediately inform the Engineer when this situation is encountered. A special consideration shall be given to the sizing of the connections from schools, clubs, hospitals, mosques, high-rise buildings or any other institutional, commercial and industrial establishments.

- 3- Before Inspection Chamber can be made the Contractor will have to accurately locate, both in plan and elevation, the existing building sewer . After this is done the Contractor shall make a layout of all sewer connections to the street sewer manholes. This layout shall conform with the typical Inspection Chamber piping arrangements shown on the drawings. At this time any necessary adjustments in the given street sewer slope and depth can be made with the approval of the Engineer.

- 4- it is intended that all Inspection Chamber piping discharge directly into sewer manholes without the need for utilizing backdrop manhole connections. Up to 4 house connection Chambers can be interconnected and discharge through one pipe into a sewer manhole.

B- IMPLEMENTATION OF PROGRAM

- 1- Connection to new tested and accepted sewers.
- a. No Inspection Chamber will be connected to a street sewer that has not been tested and accepted.
 - b. Normally all building sewer connections shall be done to Inspection Chambers and intern house connection Chambers shall be connected to street sewer manholes.

C- RECORDS OF CONNECTIONS

The Contractor shall maintain a log of the Inspection Chamber made to the sewerage network recording the diameter, Length, grade of the connection pipe and its invert elevation at the property line. The log shall also note the location, description and elevation of each obstruction crossed by the building connection and a description of the protection, if any, provided. The log shall be kept in a standard survey log book approved by the Engineer. Notes shall be recorded in a form satisfactory to the Engineer and shall be available for his inspection on request. Upon completion of the contract, the log book or a true copy thereof shall be handed over to the Engineer .

D- TESTING OF HOUSE CONNECTION PIPING

The Asbestos cement pipe or vitrified clay pipes or PVC between the house connection Chamber and the street sewer manhole shall be tested as per section 02610 for gravity or section 02621 or Section 02622 for gravity . The piping between the building and the house connection Chamber will be inspected by the Engineer before backfilling.

E- CLEARING

All new Inspection Chambers shall be thoroughly cleaned of all silt, debris and foreign of any kind, prior to final Inspection.

End of Section

SECTION 02623
UNPLASTICIZED POLYVINYL CHLORIDE
(U.P.V.C.) PIPE

PART 1 - GENERAL

1.1 SCOPE OF WORK

- A- Furnish all labor, materials, equipment and accidentals necessary to install and test Unplasticized Polyvinyl Chloride (U.P.V.C.) pressure pipe, Unplasticized polyvinyl chloride (U.P.V.C.) sewer pipe and all appurtenances as shown on the Drawings and as specified herein.

1.2 RELATED WORK NOT INCLUDED

- A- Excavation, trenching, backfilling is included in Section 02210.
- B- Granular materials are included in Section 02210.
- C- Groundwater control is included in Section 02275.
- D- Concrete is included in Division 3.

1.3 SUBMITTALS

- A- Submit to the Engineer within thirty days of the Effective Agreement, the names of the pipe and fitting suppliers and a list of materials to be furnished.
- B- Submit to the Engineer as provided complete detailed working drawings and schedules of all (U.P.V.C.) pipe and fittings required.
- C- Prior to shipment of pipe, submit certified test reports that the pipe for the Contract was manufactured and tested in accordance with ASTM Standards specified herein.

1.4 QUALITY ASSURANCE

- A- All (U.P.V.C.) pipe and fittings shall be from a single manufacturer. All (U.P.V.C.) pipe to be installed under this Contract may be inspected at the plant for compliance with these Specifications by an independent testing laboratory selected by the Employer.
The Contractor shall require the manufacturer's cooperation in these inspections.

- B-** Inspect visually all pipe and fittings delivered to the site for conformance with this specification. Inspection of the pipe will also be made by the Engineer or other representatives of the Employer after delivery. The pipe shall be subject to rejection at any time on account of failure to meet any of the Specification requirements, even though pipes may have been accepted as satisfactory at the place of manufacture. pipe rejected after delivery shall be marked for identification and shall immediately be removed from the job.

PART 2 - PRODUCTS

2.1 MATERIALS FOR PRESSURE PIPE

- A-** Pressure pipe for irrigation lines shall conform to the requirements of ASTM D2241 U.P.V.C. pipe or DIN 8062, working pressure as required. The pipe shall be made from U.P.V.C. Compounds class 12454 -B as defined in ASTM D 1784. Each pipe length shall be marked with the manufacturer's name or trademark, size, material code, pressure class, ASTM designation number and seal of test agency that verified pipe material for potable-water service.
- B-** Pipe and fittings for U.P.V.C. sewer shall be type PSM, U.P.V.C. SDR 35 with full diameter dimensions and shall conform to ASTM D 3034. Also acceptable is U.P.V.C. (rigid P.V.C.) according to BS 5481 or DIN 8061 part 1.
1. Straight pipe shall be furnished in length of not more than 13 ft,
- C-** The pressure pipe shall be manufactured with integral bell and spigot joint conforming to ASTM D 3139.
- D-** All fittings shall be U.P.V.C. of the same manufacturer schedule number, and material as the pipe. All adapters, fittings and transition gaskets necessary to connect ductile iron pipe to U.P.V.C. pipe shall be furnished.

2.2 MATERIALS FOR GRAVITY PIPE

- A-** Polyvinyl chloride sewer pipe shall be up to 300 mm. diameter and shall conform to the requirements of ASTM D3034 SDR 41 wall thickness 3.89 mm, for polyvinyl Chloride (U.P.V.C.) Pipe. Also acceptable is U.P.V.C. (rigid P.V.C.) according to DIN 8061 part 1 wall thickness 3.6 mm. The pipe shall be U.P.V.C. 1120 made from U.P.V.C. compounds Class 12454-B as defined in ASTM D1784. Each pipe length shall be marked with the manufacturer's name or trademark, size, material code, class, ASTM designation number and seal of test agency that verified pipe material for sewage service.
- B-** The pipe shall be manufactured with integral bell and spigot joints. an elastomeric ring conforming to ASTM D1869 and F477 shall fit securely into

a deep groove in the bell end of the pipe. Also acceptable is Sealing ring according to DIN 4060 Part 1. The wall thickness of the bell shall be at least as great as that of the pipe barrel.

- C- All fittings shall be U.P.V.C. of the same manufacturer schedule number, and material as the pipe. All adaptors, fittings and transition gaskets necessary to connect U.P.V.C. pipe house plumbing house connection chambers and sewer manholes shall be furnished.

PART 3 - EXECUTION

3.1 HANDLING PIPE

- A- The Contractor's attention is called to the fact that pipe and fittings are slightly brittle. Care shall be taken in transporting, handling and laying to avoid damaging the pipe and fittings. Any pipe damaged in shipment shall be replaced as directed by the Engineer.
- B- Any fitting showing a crack, and any fitting or pipe which has received a blow that may have caused an incipient fracture, even though no such fracture can be seen, shall be marked as rejected and removed at once from the work.
- C- While stored, all pipe shall be adequately supported from below, in at least 900 mm intervals, to prevent deformation prior to installation. pipe shall be stacked to a height not exceeding 1800 mm. pipe shall be stored in a manner which will keep the pipe at ambient outdoor temperatures. Temporary shading as required to meet this requirement shall be provided. Simple covering of the pipe which allows temperature buildup, when exposed to direct sunlight will not be permitted.

3.2 LAYING U.P.V.C. PIPE AND FITTINGS

- A- If any defective pipe is discovered after it has been laid, it shall be removed and replaced with a sound pipe in a satisfactory manner by the Contractor, at his own expense. All pipes and fittings shall be thoroughly cleaned before laying, shall be kept clean until they are used in the work, and when laid, shall conform to the lines and grades required. U.P.V.C. pipe and fittings shall be installed in accordance with requirements of the manufacturer except as otherwise provided herein. As soon as the excavation is complete to normal grade of the bottom of the trench, screened gravel bedding shall be placed, compacted and graded to provide firm, uniform and continuous support for the pipe. Bell holes shall be excavated so that only the barrel of the pipe bears upon the bedding. The pipe shall be laid accurately to the grades indicated on the Drawings. Blocking under the pipe will not be permitted. Screened gravel shall be placed evenly on each side of the pipe to mid-diameter and hand tools shall be used to force the screened gravel under the

haunches of the pipe and into the bell holes to give firm continuous support for the pipe. Screened gravel shall then be placed to 300 mm above the top of the pipe.

The initial 900 mm of backfill above the screened gravel backfill shall be placed in 300 mm layers and carefully compacted.

Generally the compaction shall be done evenly on each side of the pipe and compaction equipment shall not be operated directly over the pipe until sufficient backfill has been placed to ensure that such compaction equipment will not have a damaging effect on the pipe. Equipment used in compacting the initial 900 mm of backfill shall be approved by the pipe manufacturer's representative prior to use.

- B-** All pipe shall be sound and clean before laying. When laying is not in progress, including lunchtime, the open ends of the pipe shall be closed by watertight plug or other approved means. Good alignment shall be preserved in laying. The deflection at joints shall not exceed that recommended by manufacturer.
- C-** When cutting pipe is required, the cutting shall be done by machine, leaving a smooth cut at right angles to the axis of the pipe. Cut ends of pipe to be used with a bell shall be beveled to conform to the manufactured spigot end.
- D-** Concrete thrust blocks shall be installed at all fittings and other locations as directed by the Engineer. Minimum bearing area shall be as shown on the Drawings. Concrete shall be placed against undisturbed material, and shall not cover joints, bolts or nuts, or interfere with the removal of any joint. Wooden side forms shall be provided for thrust blocks.
- E-** At location where the pipe crosses a water main or service connection or cross road the pipes shall be encased in concrete as indicated on the drawing and or as directed by the Engineer.

3.3 JOINTING U.P.V.C. PIPE (PUSH ON TYPE)

- A-** Joints shall be made in strict accordance with the manufacturer's instructions. Pipe shall be laid with bell ends looking ahead. A rubber gasket shall be inserted in the groove of the bell end of the pipe, and the joint surfaces cleaned and lubricated. The plain end of the pipe to be entered shall then be inserted in alignment with the bell of the pipe to which it is to be jointed, and pushed home with a come-along or by other means. Check that the reference mark on the spigot end is flush with the end of the bell.

3.4 TESTING PRESSURE PIPES

- A-** Furnish all necessary equipment and labor for carrying out a pressure test and leakage test on the pipelines. The procedures and method for carrying out the pressure and leakage tests shall be approved by the Engineer.

- B-** Make any tape and furnish all necessary caps, plugs, etc., as required in conjunction with testing a portion of the pipe between valves. Furnish a test pump, gauges and any other equipment required in conjunction with carrying out the hydrostatic tests.
- C-** All pipelines shall be subjected to hydrostatic pressure of 1.5 working pressure, and this pressure maintained for at least two hours. The leakage test shall be conducted concurrently with the pressure test. Hydrant branch gate valves shall remain open during this test. The amount of leakage which will be permitted shall be in accordance with the Specifications for Installation of Ductile Iron Mains, AWWA C600.

3.5 TESTING GRAVITY PIPES

A- GENERAL :

1. All plastic sewer pipe shall be tested for leakage by an infiltration test if the ground water level is a minimum of 600 mm above crown of pipe for the length of section to be tested. When this condition does not occur an exfiltration test will be required. The exfiltration test may be performed hydrostatically or by the Engineer.
2. Provide all weirs, plugs, hoses, compressors and other equipment necessary to perform all testing operations.
3. If a section of sewer fails to meet the leakage testing criteria then another test will be required after the sewer leaks have been repaired.

B- INFILTRATION TEST :

1. Pipe shall be tested for infiltration after the backfill has been placed and the ground water allowed to return to normal elevation. Infiltration tests shall be made under the supervision of the Engineer, and the length of line to be tested shall not be less than total length of each size of pipe. The allowable infiltration shall be 10 liters per millimeter of diameter per day kilometer of pipe in each section tested. There shall be no gushing or spurting leaks.
2. If an inspection of the completed sewer or any part thereof shown pipes or joints which allow noticeable infiltration of water, the defective work of material shall be replaced or repaired as directed.

C- EXFILTRATION TEST :

1. Leakage tests by exfiltration shall be made before or after backfilling at the discretion of the Engineer. The length of pipe to be tested shall be such that the head over the crown at the upstream crown is not than 600 mm and the head upstream crown is not more 1800 mm. The pipe shall be plugged by pneumatic bags or mechanical plugs in such a manner that the air can be released from the pipe while it is being filled with water. Before

any measurements are made, the pipe shall be kept full of water long enough to allow absorption and the escape of any trapped air to take place. Following this, a test period of at least one hour shall begin. Provisions shall be made for measuring the amount of water required to maintain the water at a constant level during the test period.

2. If any joint shows an appreciable amount of leakage, the jointing material shall be removed and the joint repaired. If any pipe is defective, it shall be removed and replaced.

If the quantity of water required to maintain a constant level in the pipe does not exceed 5 liters per millimeter of diameter per day per kilometer of pipe and if all the leakage is not confined to a few joints, workmanship shall be considered satisfactory. If the amount of leakage indicates defective joints or broken pipes, they shall be corrected or replaced.

D- AIR TESTING :

1. The Contractor may use an air test in lieu of the exfiltration test. If he elects to do this, he shall submit his proposed method of testing to the Engineer for acceptance. Air testing shall be performed in accordance with the procedures described in ASTM C828. The equipment shall be specifically designed and manufactured for testing pipelines with low-pressure air and shall be provided with an air regulator valve or air safety valve set to prevent the air pressure in the pipeline from exceeding 0.6 Kg/cm².

3.6 CLEANING

- A-** At the conclusion of the work, thoroughly clean all pipelines by flushing with water or other means to remove all dirt, stones, pieces of wood, or other material which may have entered the pipes during the construction period. Debris cleaned from the lines shall be removed from the low end of the pipeline. If after this cleaning, obstructions remain, they shall be removed. After the pipelines are cleaned and if the ground water level is above the pipe Engineer will examine the pipes for leaks. If any defective pipes or joints are discovered, they shall be repaired.

End of Section

PACKAGE BOOSTER PUMP SET

Furnish and install a factory assembled basic package THREE pumps booster set . The set shall require only suction and discharge pipe connections and one electric power connection .

The booster set shall consist of pumps, electric motors control center, valves and all necessary interconnecting piping for a complete package .

The pumps shall be of horizontal and suction, frame mounted type .

(The pump shall be end suction type, vertical split case type. The pump casing shall be cast iron with smooth water passage and fitted with a bronze replaceable ring. Suction and discharge connections shall be 125 lb. Class ANSI type.

The impeller shall be bronze of a diameter of not greater than 90% of the casing cut - water diameter.

The sealing of the liquid cavity shall be with a face type mechanical seal, with Ni-resist stationary seat, carbon washer . Buna rubber flexible members 18-8 stainless steel metal parts and 18-8 stainless spring.

Seal to be rated for 225 F, and will be mounted over a bronze shaft sleeve .

Motor shall be of NEMA frame totally enclosed fan cooled, rated power shall cover the pump requirement at any conditions on the pump performance curve, at 2900 RPM, 380 volts, 3 phase, 50 hertz.

The pump shaft shall be 416 stainless steel and of a size and design to limit shaft deflection, at the stuffing box to no more than .002 inches pump bearing, shall be grease lubricated, and sized for a minimum of 20,000 hour B 10 life which is equivalent to 100,000 hours average bearing life .

Moter and pump shall be aligned and mounted on a steel base . A coupling guard shall be furnished .

All components shall be mounted on a common fabricated steel base suitable for grouting .

The package piping shall consist of flanged cast iron fittings. The suction lines shall be symmetrical providing for equal friction loss, and effect on the suction approach to the pumps. Each suction line shall include an eccentric reducer. A Butterfly shutoff valve and shall teminate into a standard tee. The discharge line of each pump shall include a non slam check valve. A butterfly shutoff valve and terminate into a standard tee. Piping shall be arranged to allow removal of either pump's casing, impeller, mechanical seal without disturbing the piping or the driver and while allowing the other pump to operate within its capacity capability. All control sensing lines and gauges connections shall be piped without shutoff valves .

Each pump shall be equipped with a separate thermal safety valves, which will open and discharge water into a drain when temperature exceed the set point.

The standby pump shall be standard by drop in system pressure, and stopped by a minimum run timer in conjunction with the pressure switch . Start and stop functions shall be controlled by adjustable devices .

The electric controller shall be in NEMA 3R enclosure with main disconnect switch sized for the horsepower rating of the connected motors and control loads .

A circuit breaker, motor starter, hand-off- automatic switch, and running pilot light shall be provided for each motor .

Pump supply shall be 380 volt, 3 phase, 50 hertz.

A door handle shall be provided for the disconnect switch, so that power circuits are disconnected before the door is opened . A 120 volt control circuit with transformer , and primary and secondary fuse protection shall be furnished within the controller.

Provide audible and visible low pressure alarm, , manual reset for suction, pumps shall shutdown . Also visible motor overload pilot light .

The pump motors, pressure switches and all electric sensing devices shall be wired to the controller and shall meet the national electric code .

A system pressure switch shall be mounted, piped and wired on the side of the control enclosure, 4.5 Inch diameter discharge pressure gauge is mounted on the controller . All controls shall be functionally tested prior to shipment.

The assembled package booster set shall be hydrostatically tested and painted with shop coat of machinery enamel after test.

The pump supplier shall have the unit responsibility for the complete package . The pump supplier or his representative shall provide start up and adjustment service for the booster pump set .

VENDOR LIST :

KSB pump	Germany
Fairbanks morse pump	U.S.A
peerless pump	U.S.A

SPECIFICATIONS OF PUMP

The pump shall be electrically operated, with three or single phase 380/220 volt ., 50 c/s, Squirrel cage induction motor .

- Motor insulation shall be damp proof class.
- The rated output of the motor shall be at least 20% of the maximum power consumed by the pump at the most worst condition of loading .
- The operating speed shall not exceed 2900 r.p.m
- The stator windings shall be protected against moisture .

Delivery of the pump shall led to the nearest manhole .

ACCESSORIES :

The drainage pump shall be supplied complete with the following accessories to make it ready for operation : -

- Starter for the pump .
- Delivery hoses with suitable lengths (not less than 20 meters) .
- Single handling chain .
- A suitable length of cable with ample cross section .
- Pump will be provided with float switch for starting and stopping automatically inside the pit .

NOTE

The flexible piping hoses shall be of the best quality

EARTHING SYSTEM

The contractor shall furnish and supply a complete earthing system for the whole pumping station .

- Earthing of all equipment inside the pumping station shall be earthed by connecting all metallic parts in it to earth electrodes as specified herein .
- The metallic parts of each installation (motors) , pumps, switchboards .
- All these shall be interconnected through adequate section bare tinned copper stranded conductor of about 10 mm² (at least) fixed to the wall sides of the trenches or running through galvanized steel conduits for protecting them and ending at earthing electrodes .
- Each copper clad electrode shall consist of high carbon steel core of high strength and must be rigid for easy driving into the soil and shall be equipped with two clamps for connecting to the earth conductor which shall be pivoted.
- The electrodes shall be 2.5 meters length and 75 mm (3 inches) diameter, their number shall be not less than two and are determined to make the total earthing system resistance to ground not more than 1 ohm .
- The normally used materials for making earth are the char coal and salt, it will be mixed together in sufficient quantities to give the required ohmic resistance of the earth .

The contractor shall describe in his offer in details the earthing system which will be supplied and erected .

■

The contractor after executing the earthing system and connect all equipment in the station with it, shall measure its value to ensure its correction .

SPARE PARTS

- No (1) Drive shaft complete impeller for each pump
- No (2) Bearing set for pump
- No (2) Bearing set for electrical motor
- No (2) Glands set for each pump
- No (2) Wear ring for each pump
- Complete set from all components of control and operation panel .

Fire Fighting System Works

*** Water Boosting Plant:**

The water service booster pump set shall comprise 3 No. centrifugal pumps arranged to run as duty, and standby, unless otherwise mentioned in the bill of quantities.

The motors shall be drip proof, squirrel cage, induction motors to B.S. 2613 Class F insulation and be suitable for 380 volt, 3 phase, 50 Hertz electrical supply and working in an ambient temperature of 60° C.

The pump casting, back cover, base plate and sub frame shall be manufactured from high grade cast iron to B.S. 1452. The impellor shall be manufactured from high grade gunmetal to B.S. 1400. Casing sealing rings shall be renewable and manufactured from phosphor bronze to B.S. 1400. The pump gland shall be fitted with a self-adjusting mechanical seal.

The pump assembly shall be provided with a purpose made starter control panel containing automatic star delta starters each having 'hand' 'off' and 'automatic' positions, high and low pressure switches to operate lead/lag pumps and to automatically change over from 'duty' to 'standby' should the 'duty' pump fail to operate and a manual duty selection switch. The panel shall be provided with a lockable isolator/door interlock mechanism.

Panel shall also contain pilot lights (red) indicating power on/pump running/pump tripped.

A pressure gauge shall be fitted in the control panel, registering the pressure in the pump discharge. A flow indicator shall be fitted to the common pump suction.

A pneumatic pressure vessel shall be connected to the common flow main of sufficient capacity to prevent frequent pump starting when water is drawn off the boosted service.

Each pump shall be fitted with isolating valves on suction and discharge, together with individual non-return valves. Additionally a non-return valve shall be fitted into the common main discharge pipe work having a positive shutoff. The whole assembly shall be mounted on a purpose made base frame complete with steel pipe work, pipe supports and lifting lugs.

In-line type water circulating pumps shall be installed where shown on drawings as specified in the Specification and/or Schedule of Equipment.

The pumps shall be vertical close coupled inline type with suction and discharge flanges (of equal size) located on a common center line, 180° apart for mounting in the pipeline. The motor and shaft assembly shall be easily removable from the casing without disturbing pipe work. The pump casing shall be bronze to BNS1400 Grade LG2 or stainless steel suitable for minimum 10.0 bar working pressure.

The impeller shall also be bronze to BS1400 Grade LG2, dynamically balanced. The shaft shall be stainless steel. The pump shall be fitted with a mechanical seal of flexible bellows type. The motor shall be TEFC with class "F" insulation and rated at IP54.

The duty and standby pumps shall be controlled from an automatic control panel. A two position mode selection switch shall be provided on this Control Panel. In 'Auto' position of the mode selection switch, the operation of pumps shall be controlled by timers. In 'Manual' position of the duty selection switch, the H-O-A switches for pumps shall be in 'Hand' mode and the pump shall be switched ON/OFF using push buttons.

The control panel shall operate the pumps continuously, equalize run hours in the Auto mode, record the run time carry out auto-switchover to standby pump. 'Run' and 'Trip' indications will also be provided on the pump control panel.

*** FIREFIGHTING SYSTEM**

1 General:

The lay-out as specified, workmanship and materials of pipes and fittings shall conform to the National fire protection standards.

Portable fire extinguishers of the specified type and weight shall be sited as directed by the Engineer in prominent positions on exit routes in such a way that no person need travel more than 30m.

The extinguishers shall be supported so that the handles are 1.00 m above floor level, and shall be fixed in similar positions on each floor.

All similar extinguishers in building shall be of the same method of operation.

The hydraulic hose reels shall be located in a prominent position at each floor level on exit routes preferably in corridors in such a way that the hose can be taken into every room and within 6.1 m of each part of the room, having regard for any obstruction.

The piping as specified or shown on the drawings shall be completed in a neat and workmanlike manner with necessary clamps and supports. The piping shall be interconnected and provided with adequate No. of valves to permit desired flexibility in control. The valves shall be of the outside screw and yoke pattern and shall be prominently located and labeled.

The hose shall be of red rubber 19mm/25mm smooth hose or of the specified size with a working pressure of 4.5bar and of the specified length from 18.30 - 36.60 m terminating in 6.0mm nozzles as specified.

Each reel shall be connected by a short 40 mm branch pipe with shut off valve.

At each floor at the hose reel connection, an recessed swinging hose reel cabinet with door supporting bracket for installation, of adequate dimensions to enclose the hose reel shall be provided.

A laminated plastic instruction plate shall be supplied with each reel. An adjustable type pressure reducer shall be provided between the hose and standpipe to protect the hose against excessive pressure beyond 350 kPa.

Approved expansion joints shall be provided where necessary.

The installation of the system shall closely follow the construction of the building to provide protection during the construction period.

All pipes, fittings and connections shall be supplied and made in accordance with the recommendations of the equipment manufacturer, who shall furnish detailed drawings, performance curves and other characteristics which shall conform to the fire pump standards.

The contractor shall provide the necessary number of skilled men to assist in the testing and commissioning of fire pumps, auxiliary equipment and the hydraulic hose reel system. The installation shall pass the required tests of National electrical codes, except as otherwise modified by the fire pump standards.

The external hydrants, where specified, UL listed, FM approved shall be. The hydrants shall be located around the building at not less than 12m from the building to be protected and in readily accessible places for use by the fire dept.

2 Hydrant Main Pump Set:

The main hydrant shall be served by a packaged pumping set electric and diesel complete with jockey pump. The pump shall each be rated at the duty detailed in the Schedules. The motors shall be drip proof, squirrel cage induction motors. The jockey pump shall be rated at the duty detailed in the Schedules. The pumps should be UL listed, FM approved.

The pump assembly shall be provided with a purpose made starter control panel containing automatic star delta and one direct on line starters, each having 'hand' 'off' 'automatic' positions, 220 volt operating coils, flow switch, transformer and relays and time delay unit to automatically change over from 'duty' to 'standby' pump should the 'duty' pump fail. The control panel shall be provided with lockable isolator/door interlock mechanism.

A flow switch shall be provided in the common line to continue operation of the duty pump by over-riding the pressure switch as detailed below, when draw-off exists.

The jockey pump shall cycle 'on' and 'off' to maintain the system under pressure by means of a pressure switch set at predetermined pressures.

Duplicate pressure switches shall be provided in the electrical control panel to switch on the duty pump when the system pressure drops below the set value. Should the duty pump be unable to maintain pressure, the standby pump shall be started.

Low level alarm switches shall be provided in the fire reservoir. Each pump shall be fitted with isolating valves on the suction and discharge together with non-return valves. Additionally a non-return valve shall be fitted on the common main discharge.

The control panel shall be fitted with pressure gauge connected to the pumps common discharge connection and a flow indicator shall be fitted in the pumps common suction.

The whole assembly shall be mounted on a purpose made base frame, complete with pipe supports, interconnecting pipe work, including test by-pass, lifting lugs and flexible connections on suction and discharge pipe work.

Ministry of Electricity (MOE)
Power Distribution Office
Baghdad - IRAQ

SPECIFICATION No.	D-26
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DISTRIBUTION TRANSFORMER
11 / 0.416 kV

REVISION	YEAR 2013
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DISTRIBUTION TRANSFORMERS

1- SCOPE OF THE TENDER :

Tenderer are invited for the design , manufacture , testing and supply of a 11000/416 volt, oil immersed copper winding outdoor type (Directly under the sun) transformers to be supplied complete with all necessary fittings , accessories off-load tap changer , insulating oil and spare parts . etc.

The transformer is to be hermetically sealed (without conservator tank) bolted cover with bushing insulators on both H.T and L.T sides for the following rating: 100, 250, 400, Box type for rating 630 and 1000 KVA. And a valid ISO 9001 certificate.

2- GENERAL REQUIREMENTS :

The transformers shall be of first class quality and design for continuous satisfactory operation as continuity of supply is of prime consideration. The design shall be allow all necessary precaution for the safety of operation and maintenance personnel. The transformers shall operate satisfactorily under variations of load, voltage or short circuit or other conditions which may occur on the system provided that these variations are within the assigned rating of the apparatus. All the equipment shall be designed to obviate the risk of accidental short circuit.

2-1 Climatic Conditions:

The materials used shall be suitable for the following climatic conditions prevailing at the site:

2-1-1 Ambient temperature:

Highest maximum (in the shade) +55C for about 6 hrs a day.

Lowest minimum -10C

Maximum yearly average +30C

Maximum daily average +40C

2-1-2 Solar Temperature:

Black objects under direct sunshine attain a temperature of 80 °C.

2-1-3 Air humidity :

Maximum	92% at 40° C
Minimum	12%
Yearly average	44%

2-1-4 Sand storm:

In general the atmosphere is dusty which may result in a layer of dust being deposited on all exposed surfaces. Also fine dust particles may penetrate even through minute openings.

2-2 Altitudes

From sea level up to (1000m)

2-3 System Data:

2-3-1 High voltage side:-

Nominal voltage	11000 Volts
Short circuit level	25 KA at 11000 volts
Frequency	50 HZ.
Highest system voltage	12000 volts
system	3- phase,3-wire with neutral isolated but provision is made for earthing through an earthing resistance of 21.1 ohms to limit the earth fault current to 300 Amp.

2-3-2 Low voltage side:-

Nominal voltage: 416/240 volts
system

3-phase, 4-wire neutral
solidly earthed.

Short circuit level

According to the short circuit level of H.T side and the rated power and impedance voltage of the transformer

2-4 Standards:

All the equipments shall be in accordance with the latest issue of the international Electro – technical commission (IEC specification).

2-5 Deviation:

The tenderer shall particularly mention in his tender all deviations from the specification described in these tender specification.

2-6 Schedules:

The tender shall duly fill in the schedules A&B of guaranteed technical particulars, prices, delivery and deviations attached to this specification. Incomplete tenders are liable to rejection.

2-7 Guarantee:

The tenderer shall confirm that the transformer guaranteed against all defects arising from faults design, materials and workmanship, for a period of (12) months from commissioning or (18) months from arrivals, whichever period expires earlier.

3- system composition

The transformer shall operate in distribution systems where most of the network is overhead lines and comprising partly underground cable.

4- TECHNICAL SPECIFICATION

The transformers shall be copper winding. Hermetically sealed of the bolted cover and should have the following characteristics:-

Rated outputs ONAN 100, 250, 400, 630, and 1000 KVA.

Duty.....step-down, outdoor bushing type for 100,250,400, Box type for 630 & 1000 KVA (either steel box type or plug in type according to the tender documents).

Typewound, 3-phase

Rated voltage at no load H.V. 11kv L.V- 416 volt.

System frequency50HZ

Interphase Connection ... H.V. Delta L.V- star with neutral brought out.

Vector relation ship Dyn 11

Type of Cooling ONAN

- ❖ Temperature rise(i) 45 K in top oil by thermometer
(ii) 50 K in winding by resistance.
- ❖ The efficiency (at unity power factor and 100% of rated power) of the transformer should be not less than the following:
 1. 100 kVA 98.1%
 2. 250 kVA 98.6%
 3. 400 kVA 98.7%
 4. 630 kVA 98.8%
 5. 1000 kVA 98.9%
- ❖ The duration of the short circuit to rise the temp. of windings from 105⁰ C to 250⁰ C should be not less than (5 Sec.) according to IEC 60076-part 5 – clause (4.1.5).
- ❖ The thickness of the radiator plates should be shock resistant and don't affect heat dissipation according to tender requirements.
- ❖ The noise level should be ≤ 55 dB at 0.3 meter distance according to IEC standards.
- ❖ The low voltage winding must be of copper foil for 250, 400, 630 & 1000KVA transformers.

- ❖ Off-load tap changer five tapping for (– 2.5%, – 5%) on the H.T winding for off-circuit operation externally. The mechanical operation must be of the robust and definite position type with a click indicating position arrived during tap changing with suitable pad-lock.
- ❖ System Highest Voltage . . H.V side 12 kV
- ❖ Terminal arrangement of transformers:-
 - The 11 kV side terminal is to be a clamp type with eyebolt or flat bar type with nut suitable for conductors up to 150 mm² copper (for 100, 250, 400 KVA).
 - For 630, 1000 KVA the 11 kV side terminal is to be flat bar only.
 - The low voltage terminals are to be flat bar type with holes suitable for compression type thimble the sizes of L.V side:
 - ✓ For 100 KVA transformer 4x1x70 mm² copper (1 hole per phase).
 - ✓ For 250 KVA transformer 6x1x95+1x70 mm² copper (1 hole per phase).
 - ✓ For 400KVA transformer 7x1x150 mm² copper (2 holes per phase).

Terminal arrangement of outdoors transformers must be porcelain bushing insulator (brown colored preferable) mounted on the top cover of transformer for both H.T. and L.T, with arcing horn (double air gap is preferable) on H.T. bushing for outdoor transformer only. Neutral bushing should be distinguished from phase bushing.

- For 630 & 1000 kVA transformers should be either box-type or plug-in type for H.V. side (according to the tender requirements) with glands and cable holes suitable for cable size of 1 x 50 mm², 12/20 kV.
- For L.V. side with glands and cable holes suitable for cable size of 1 x 240 mm².

The cables arrangement as specified below:

- ✓ For 630 KVA transformer 11x1x240 mm² copper (4 holes per phase).
- ✓ For 1000 KVA transformer 14x1x240 mm² copper (4 holes per phase).

5- Fittings and Accessories:

- Terminal marking plate.
- Tapping switch.
- Two valves (3/4 inches) diameter fitted on cover and bottom of tank, switch locks.
- Thermometer pocket with thermometer including max temp. measurement indicator with two separate free contacts.
- Lifting lugs.
- Pressure relief valve.
- Earthing terminal on tank.
- Rating and diagram plate to be chromium plated of the engraved type with kVA rating and serial number engraved on the cover of the transformer at a suitable place.
- Skid mounting to be vertical with the length of the transformer.
- Oil level indicator, to be of mechanical type located on the top cover of transformer to indicate the oil level with the temp variation, protected by metallic envelopes.

6- Painting

- The painting should be oil and weather (dust, humidity and heat etc.) resistant type and the final coat is to be aluminum paint or equivalent. Any alternative finishing which gives better heat radiation is accepted and must be confirmed by calculations.
- Ministry of Electricity logo must be engraved on the cover of the transformer at a suitable place.

7- Insulating oil

The transformer is to be shipped with first filling of oil which shall be (uninhibited insulation oil), according to the latest IEC 60296.

8 - Tender Price Evaluation (losses considerations)

The following equation will be applied to calculate the cost of transformer, considering the age of the transformer, the iron losses and copper losses and the initial price of the transformer. This cost will be used for comparison the values of the tender and not the initial price of the transformer.

Ie = Iron (no-load) losses: 1800 USD per kW at rated voltage and frequency.

Cu = Copper (Load) losses: 600 USD per kW at rated power and principle tapping at 75°C

Cost according to loss evaluation (for one transformer) = Initial price + (Guaranteed Ie x 1800 + Guaranteed Cu x 600)

8-1 Loss evaluation

The tolerance permitted is +10% of the evaluated guaranteed total losses mentioned in the offer. Any transformer with total losses more than + 10% will be rejected. For transformer with total losses within +5% of the evaluated guaranteed losses, no penalty shall be made. For transformers where the total losses between 105% to 110% of the total evaluated guaranteed losses , the contract price shall be reduced by the cost of the difference between the total losses and the 100% of the total evaluated guaranteed losses according to the following values.

Ie = Iron losses (kW).

Cu = Copper losses (kW).

Q = number of transformers required in the tender.

For any transformer with total losses less than 100% of the guaranteed losses , no variation to the contract price shall be made.

Total penalty (USD) = Q x [(Measured Ie- Guaranteed Ie) Kw x 1800 USD/kW + (Measured Cu - Guaranteed Cu) kW x 600 USD/kW]

9- Test

9-1 Inspection:

The transformer materials shall be inspected and tested by the owner inspectors or international inspector at any time during manufacturing.

The manufacturer shall provide all inspection facilities for the mentioned inspection and the inspection shall be made at the place of manufacture or at international testing facilities according to the tender requirements.

The inspector shall have the right of rejecting any portion of the material at any time during manufacture if it does not meet with the requirements of this specification in all particulars. He shall have the right of overseeing the packing and shipping of all material to be supplied.

9-2 Test at manufacture work:

Test at manufacture's factory shall comprise type tests (if required according to the tender requirements) and routine tests according to the approved parameters in schedules A & B.

a-Type tests

The type test prescribed shall be carried out on one unit of each capacity

- 1- Test of temperature rise according to the latest IEC 60076.
- 2- Full - wave impulse-voltage withstand test according to the latest IEC 60076.
- 3- Cost of these tests to be borne by the manufacturer.

b- Routine tests

Each transformer shall be subjected to all the routine tests specified according to the latest IEC 60076.

c- Special tests (if required according to the tender requirements).

9-3 Test reports:

Five copies of the test reports will be mailed within 8 days after the tests have taken place. These reports will indicate:

- The results of the tests.
- The calculation of performance of the items.
- The guarantee figures to show that each apparatus performs the conditions of the specification within the guaranteed values (schedules A & B).

9-4 Test Certificates:

The tenderer shall furnish the Ministry of Electricity (MOE) with 6 copies of test certificates.

No equipment shall be shipped without obtaining the (MOE) inspector prior approval of the certificates.

9-5 Witnessing tests:

Unless otherwise agreed to, all tests at factory shall be witnessed by an authorized representative from (MOE).

The cost of travelling & accommodation of the authorized inspectors to witness the test at the place of manufacture for required days, to be on tenderer account.

10- Drawing , Instruction Book And Litreature.

10-1 document to be submitted with the tender:

The following documents shall be submitted by the tenderer along with his offer:-

- a- Full technical specification of transformer including schedule A&B of guaranteed technical particulars.
- b- An outline drawing showing the plan , front and side elevation of the transformers , dimensions , terminals , equipment , and all accessories of the transformers.
- c- Catalogues of the manufacturer for transformers.
- d- Valid ISO-9001 certificate of the manufacture r for transformers.
- e- Test certificate for identical transformers.
- f- Reference list of manufactured and exported transformers.
- g- Incomplete offers are liable to rejection.

10-2 Document to be furnished by the successful tenderer:

Within a period of 2 weeks from the commencement date, the successful tenderer shall furnish the following documents for final approval:-

- a- 24 sets (or according to the tender requirements) of prints on paper on all drawings.
- b- 24 copies (or according to the tender requirements) of all instruction books and technical maintenance of the transformer, OFF Load tap changing gear and other ancillary equipment.
- c- 24 copies (or according to the tender requirements) of instruction for erection of the equipment.
- d- 24 copies (or according to the tender requirements) of spare parts list with catalogue number.

10-3 Language:

The language to be used in the drawings and instruction book shall be English.

10-4 Dimensions:

Due to the space requirement in our system it is important for the participants in this tender to make sure that the dimension of each type of the required transformers to be as small as possible the following table is indicative as a maximum for each single dimension:-

Table of Dimensions

Transformer (KVA)	Length (mm)	Width (mm)	Height (mm)
100	1220	600	1200
250	1230	700	1300
400	1400	1000	1400
630	1500	1200	1600
1000	1700	1400	1800

10-5 Approval of drawings:

The successful tenderer shall prepare and submit to the (MoE) all necessary drawings and specifications (schedule A & B) complete with explanations in due time and obtain approval of the same before commencing manufacture.

Failure to comply with this clause shall make the equipment or parts there of liable to rejection.

11- Packing

The supplier will pack or protect the goods in the most appropriate manner.

He will be responsible for any loss or damage arising from careless packing or protection up to the place of final destination after completion of the inspection and tests at the factory, each item shall be packed for export shipment. All parts provided for shipping purposes only and which are to be removed at the time of erection shall be conspicuously tagged.

The method of packing shall be such as to protect all the items against excessive corrosion of dampness, and shall afford adequate protection against breakage or other injury, or loss due to breakage of cases or crates from the time leaves the factory until reaches the final destination, the apparatus will travel by rail by a long sea voyage again by rail or truck to the site of the substation. The equipment will also undoubtedly stand on wharves and in the open during and in between periods of transportation and will thereby be exposed to heavy rain, hot sun, humid climate and sudden changes of temperature.

Owing to the numerous handlings, the containers should be very strong also extra ordinary care should be given to the packing of the equipment and especially the items having insulating material to prevent the injury due to moisture, from sources external to the packing or from excessive condensation with the packing.

12- Spare parts and special tools for each rating

12-1 Spare parts:

1-	H.T / L.T winding.	3%
2-	H.T bushing with it's accessories.	10%
3-	L.T bushing with it's accessories.	10%
4-	Tap changer.	3%
5-	Pressure relief valve.	2%
6-	Oil level indicator.	10%
7-	Cover gasket	10%

Note: Unit price per set and per piece for each item are required separately.

12-2 Special tools:

All special tools required for maintenance of transformer shall be included in the scope of supply. An itemized list of special tools together with prices shall be submitted with the tender.

SCHEDULE ((A))
SCHEDULE OF THE GUARANTEED PERFORMANCE AND
OTHER TECHNICAL PARTICULARS
(TO BE COMPLETED BY THE TENDERER)

Unit	100	250	400	630	1000
	KVA	KVA	KVA	KVA	KVA
	Tr.	Tr.	Tr.	Tr.	Tr.

- 1- Name of manufacturer.
- 2- Country of origin.
- 3- Standard on which performance data is based.
- 4- Continuous maximum rating for the specified temperature rise and ambient temperature ONAN rating (KVA)
- 5- Rated temperature rise (K)
 - a- Oil by thermometer.
 - b- Winding by resistance.
- 6- Hottest spot temperature rise (K).
- 7- No-load voltage ratio at normal tap & vector relationship.
- 8- Exciting current referred to H.V. and 50 Hz at - (Amps)
 - a- 90% rated voltage.
 - b- 100% rated voltage.
 - c- 110% rated voltage.
- 9- Power factor of exciting current at 100% rated voltage and 50 Hz.....
- 10- Iron losses at 50 HZ (kW).
 - a- 90% rated voltage.
 - b- 100% rated voltage.
 - c- 110% rated voltage.
- 11- Copper losses at full load (on rating) and at 75⁰ C (kW)
- 12- Total losses (kW).
- 13- Resistance voltage at full load and 75⁰ C (%).
- 14- Reactance voltage at full load and 75⁰ C (%)
- 15- Impedance voltage at full load and 75⁰ C (%)
 - a- At normal tap.
 - b- At highest tap.
 - c- At lowest tap.
- 16- Resistance of H.V. winding per phase at 20⁰ C (ohms).
- 17- Resistance of L.V. winding per phase at 20⁰ C..... (ohms).
- 18- Regulation at full load at 75⁰ C (%)
 - a- 1.0 power factor.
 - b- 0.8 P.F lagging.

- 19- Efficiency at 75° C (%)
 - a- 100% load
 - b- 75% load
 - c- 50% load
 - d- 25% load
- 20- Calculated thermal time constant (Hrs).
- 21- Maximum flux density at normal voltage and frequency and at normal ratio (KI/sq.cm)
 - a- core
 - b- yoke
- 22- Maximum flux density at 110% voltage and frequency and at normal voltage and frequency and at normal ratio (KI/sq.cm)
 - a- Core
 - b- Yoke
- 23- Insulation of
 - a- Core bolts
 - b- Core bolts washer
 - c- Side plates
 - d- Core laminations
- 24- Current density in windings – Amps/sq.cm.
 - a- H.V. winding
 - b- L.V. winding
- 25- Insulation on copper
- 26- Insulation strength of winding.
 - a- Impulse full wave(kV)
 - (I) H.V.
 - (II) L.V.
 - b- Impulse chopped wave(kV)
 - (I) H.V.
 - (II) L.V.
 - c- Applied voltage test kV)
 - d- Induced voltage test (kV)
- 27- Insulation strength of terminals.
 - a- Over voltage test(kV)
 - b- Minimum wet withstand voltage (kV)
 - c- Minimum impulse withstand (kV)
 - d- Minimum puncture or oil-immersed withstand voltage(kV)
- 28- Type of core
- 29- Tap changer
 - a- Manufacturer
 - b- Type

- c- Step of one tap in per cent of rated voltage
- 30- Thickness of transformer tank (mm)
 - a- Sides
 - b- Bottom
 - c- Corrugated radiators
- 31- Weights and dimensions
 - a- Net weight of core (Kg)
 - b- Net weight of copper (Kg)
 - (i) H.V.
 - (ii) L.V.
 - c- Net untanking weight of
 - (i) Core (Kg)
 - (ii) Frame(Kg)
 - (iii) Coil (Kg)
 - d- Volume of insulating oil(liter)
 - e- Net weight of insulating oil (Kg)
 - f- Total weight of transformer less oil(tons)
 - g- Weight of the largest shipping package (tons)
 - h- Crane lift for untanking core and coils (m)
 - i- Crane lift for removal of bushings (m)
 - j- Dimensions of transformer (m)
 - (i) Under base to top most point
 - (ii) Under base to bushing mounting flanges
 - (iii) Overall breadth
 - (iv) Overall length
 - k- Overall shipping dimensions of tee largest package.
- 32- Noise level dB at 0.3 (m).

SCHEDULE "B"

OIL CHARACTERISTICS TABLE (TO BE COMPLETED BY THE TENDERER)

<u>NO.</u>	<u>DESCRIPTION</u>	<u>UNIT</u>
<u>SPECIFICATIONS</u>		
1.	MAKER'S NAME	
2.	REFERENCE NAME OF OIL	
3.	SLUDGE VALUE	(Wt %)
4.	FLASH POINT (CLOSED)	°C
5.	POUR POINT	°C
6.	VISCOSITY AT:	
	a. 40° C	mm ² /s
	b. -30° C	mm ² /s
7.	ELECTRIC STRENGTH (BREAKDOWN	(KV)
8.	ACIDITY(NEUTRALIZATION VALUE)	
	a. TOTAL	mg KOH/g
	b. INORGANIC	mg KOH/g
9.	COPPER DISCELERATION	
10.	CRACKLE	
11.	SPECIFIC GRAVITY	
12.	SULFUR CONTENT	
13.	DIELECTRIC DISSIPATION FACTOR	(tan δ)

مواصفات فنية لمانعات الصواعق
11KV and 33KV

SPECIFICATIONS

FOR

METAL OXIDE SURGE ARRESTERS

SCOPE

- This Distribution Materials Specification describes the minimum technical requirements for design, materials, manufacturing, testing, inspection, delivery and performance requirement for surge arresters for 11KV and 33KV to be used in the overhead distribution system .
- The surge arresters and its fittings shall withstand effect of direct solar radiation at their installed locations. The temperature of exposed surfaces shall be regarded as 80C plus the effect of internal heating.

SYSTEM PARAMETER	SYSTEM	
	11KV	33KV
Frequency	50 HZ	50 HZ
Nominal Voltage	11KV	33KV
Highest System Voltage	12KV	36KV
Creepage Distance	25/40mm/KV	25/40mm/KV

- This covers one type surge arrester namely Metal oxide non-linear resistor type gapless, designed for outdoor service and shall be housed in sealed casing to prevent ingress of moisture and dust.

Duty Class:

- Surge arrester distribution classes shall be as defined in IEC 60099-4.

- 10KA Arrester-heavy duty class.

- Over Pressure Relief Device:

Arrester shall be provided with a pressure relief device, a mean for relieving internal pressure in an arrester and preventing explosive shattering of the housing following prolonged passage of flow current or internal flashover of the arrester.

- Disconnection Feature:

Disconnecter shall be incorporated. It is a device for Disconnecting an arrester from the system in the event of arrester failure to prevent a persistent fault on the system and to give visible indication of the

All the insulator shall have the rated withstand voltage Given in Table No. 1. Creepage distance is based on Nominal line-to-line voltage and shall be 25/40mm/KV minimum for dry and wet areas respectively. Insulator sheds shall be designed to minimize trapping of contamination . It be made porcelain having glazed brown color.

MARKINGS:

Each arrester shall be provided with a name plate, bearing the following information as a minimum, in English and/or Arabic:

- Rated voltage .
- Nominal discharge current .
- Short circuit level .
- Maximum continuous operating voltage (MCOV).
- Manufacturer's name or trademark .
- Year of manufacture .
- Country of origin .
- Manufacturer serial number .

Type Tests:

All arrester shall be fully type tested in accordance with the IEC .

Routine Test:

Supplier shall provide detail of the routine tests, which will be performed on the arresters with the minimum requirement being following .

Leakage current test:- Measurement of the leakage Current of the arresters at voltage to 100%, 80% and 60% of the rated voltage .

Power frequency reference or low current .

Residual voltage test .

Insulator tests .

**Ministry of Electricity
Planning and Studies Office**

Baghdad – Iraq

SPECIFICATION NO.

D-25

**TECHNICAL SPECIFICATION
OF
EXPULSION FUSE CUTOUT**

REVISION

YEAR 2015

1.0 SCOPE:

This tender includes for the manufacturing, testing, packing, shipping, of outdoor type expulsion fuse cutouts.

2.0 SERVICE CONDITIONS:

The materials shall be of first class quality and designed for continuous satisfactory operation as continuity of supply is of prime importance and to operate satisfactorily under variation of load, voltage and short circuit or other conditions which may occur on the system provided that these variations are within the assigned rating of the apparatus. The materials used shall be suitable for the following climatic conditions.

2.1 Ambient temperature:

Highest maximum (in the shade) 55 °C for about 6 hours a day

Lowest minimum (-10) °C

Maximum yearly average (+30) °C

Maximum daily average (+40) °C

2.2 Temperature under sun:

Black objects under direct sunshine attain a temperature of 80 °C

2.3 Air humidity:

Maximum 92% at 40 °C

Minimum 12%

Yearly average 44%

2.4 Altitudes:

From sea level up to (1000m)

2.5 Sand storm:

The equipments shall be suitable for outdoor installations and subjected to frequent sand storms and heavily polluted atmosphere.

3.0 APPLICABLE CODES AND STANDARDS:

The latest revision of the following codes and standards shall be applicable for the equipment/materials covered in this specification. In case of any deviation, the vendor/manufacturer may propose equipment/material conforming to an alternate code or standard. However, the provision of MOE standards shall supersede the provisions of these alternate standards in case of any difference.

<u>IEC</u>	<u>International Electrotechnical Commission</u>
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- | | | |
|-----|-------------|---|
| 3.1 | IEC 60060 | High voltage test techniques. |
| 3.2 | IEC 60168 | Test on indoor and outdoor post insulators of ceramic material or glass for system with nominal voltages greater than 1000 V. |
| 3.3 | IEC 60282-2 | High voltage fuses part2: Expulsion and similar insulators. |
| 3.4 | IEC 60437 | Radio interference test on high voltage insulators. |
| 3.5 | IEC 60507 | Artificial pollution test on high voltage insulators to be used on A.C system. |

3.6 ANSI C 37.41 Design tests for high voltages fuses, distribution including air switches, fuse disconnecting switches and accessories.

3.7 ANSI C 37.42 Specification for distribution cut outs and fuse links.

NEMA National Electrical Manufacturers Association.

3.8 NEMA S.G 2 High voltage fuses

Note: In case of any deviation from the listed standards, it should be indicated in the list of deviations submitted by the supplier.

4.0 TECHNICAL REQUIREMENTS (DESIGN AND CONSTRUCTION):

4-1 System Data

a. 33KV System	
33000 volts	Nominal voltage
36000 volts	Highest system voltage
3-phase, 3 wire with neutral grounding zig-zag transformer to limit the earth fault current to 1000 Amp.	System
50Hz	Frequency
25KA. r.m.s at 33000 volts.	Short circuit breaking current

b. 11 KV System	
11000 volts	Nominal voltage
12000 volts	Highest system voltage
3-phase, 3 wire neutral earthed through resistance of 21.1 Ohm limiting the earth fault current to 300A	System
25 KA R.M.S at 11000 volts	Short circuit breaking current

The cut out is fastened on a common cross arm which can be of steel, The contacts of the expulsion fuses are chosen in such a way as to ensure reliable contact pressure and drop out of the fuse carrier when operating.

The fuse carrier consists of an insulating tube into which the fuse link is built-in. The fuse link consists of a standard copper wire and a gauged silver wire as a fuse element. The fuse links are designed for standard rated current from 10A to 50A.

By its methods of operation the expulsion fuse cut outs is a switch-disconnector which breaks current within approximately 20msec and does not limit the current. After the fuse element is being melted the fuse carrier drops out from the upper fuse-base contact and performs reliable disconnection. The use carrier stays hanging on the bottom of the fuse-base contact. The operation of operator removes the fuse carrier by an insulating rod, insert a new fuse link and close it again. Expulsion fuse cutouts are applied as protection for distribution transformers and supply mains especially for the protection against the undesired action of the short circuit current and earth fault current. Technical data, dimensions, catalogues required. The expulsion fuse cutouts should be supplied with the necessary element fuses rating 20A, 40A according to the approval of the client.

4.2 Minimum Dielectric withstand values:

4.2.1 Power frequency withstand 1min Dry and wet.

To earth and between poles. 24, 33 kV ----- 50, 70 kV

Across the isolating distances. 24, 33 kV ----- 60, 80 kV

4.2.2 Impulse (1.2x 50 μ sec)

To earth and between poles. 24, 33 kV ----- 145/170 kV

Across the isolating Distances 24, 33 kV ----- 145, 200 kV

4.3 Fuse tube:

Fuse tube shall be bone fiber lined epoxy fiber glass with exterior ultra violet (U.V) protected, solid cap and single vented with arc shortening rod. Solid link shall also be used in place of as and when required.

4.4 Main assembly construction:

The main assembly shall be mounted on a single insulator of 660 mm creepage distance in the case of 24 kV fuse cutouts and single insulator along with stand off insulator arrangement of total creepage of 825 mm or 1320 mm for 33 KV fuse cutouts.

4.5 Mounting arrangement:

The expulsion fuse cutouts shall be suitable for vertical mounting. NEMA brackets shall be provided for both type of expulsion fuse cutouts. The brackets including bolts, nuts, lock washers etc. shall be in accordance with ANSI C 37.42 to prevent swiveling. The upper, lower fuse unit and fitting shall be reusable. The fuse holder shall be easy to operate with hot stick.

4.6 Contacts:

All contacts shall be designed to give continuous rated current carrying capacity after exposure to marine and desert climates for the service life. Contacts shall be silver clad on each side. Embossed surfaces with wiping action are preferred. Top and bottom contacts, sub assemblies and mounting fitting shall be potted into the porcelain insulators. The upper fixed contacts assembly shall not be corroded when exposed to atmosphere. Upper contacts shall positively latch in the closed position. The lower contacts shall be with stainless steel backup springs to prevent arcing that may occur as the fuse tube rises slightly in the hinge during operation.

4.7 Terminals:

The terminals shall be made in such away that ACSR/AW conductors can be connected without any risk of corrosion. The material used shall be copper and plated with suitable alloy. The terminals shall be of parallel groove type and shall be suitable for the standard sizes of conductors used by MOE.

4.8 Insulators:

The insulators shall be porcelain and bird proof. There shall be no steel bands around the insulator. In case of stand off insulator, the insulators shall be rigidly connected to the channel base where provided so that deflection of the insulators under short circuit conditions is kept to a minimum and there is no tendency for them to work loose from base. All the openings in the insulator shall be completely potted with inorganic sulfur cement and all exposed areas of the sulfur cement shall be coated with an enamel- based paint to minimize the ingress of moisture.

4.9 Load break hook:

The expulsion fuse cutouts shall be provided with load break hooks to facilitate the use of portable load break tools. The attachment hooks shall be made of galvanized steel, not less than 9.54 mm (3/8" in) diameter. They shall be resistance welded to the upper contacts assembly. Spot welding, which can produce localized rust and weaken the hooks, shall not be acceptable.

4.10 Galvanizing:

All iron components shall be galvanized. The supplier /vendor shall state weight / thickness of zinc coating on the attached technical data schedule.

4.11 Construction:

The expulsion fuse cutout shall be designed suitable for pole mounting on cross arms. Therefore it should be supplied completely with fuse holder and fuse link elements with holder bimetal clamp connectors. The fuse link element shall be of a current limiting type in accordance of IEC 60282. The rating of both 33 and 24 kV fuses cutouts shall be 100A.

4.12 Short circuit interrupting ratings:

The fuse cut-out short circuit interrupting ratings should be according to the following table:

current rating (A)	BIL (kV)	Rated voltage (kV)	#
100	145	24	1
100	200	36	2

4.13 Deviations

The tenderer shall particularly mention in his tender all deviations of his offer from the specifications described in these tender documents.

5.0 MARKING:

Each fuse tube shall be permanently marked with the following information as minimum, in English and /or Arabic.

- 5.1 Rated voltage
- 5.2 Maximum continuous current rating.
- 5.3 Rated interrupting current symmetrical.
- 5.4 Basic insulation level.
- 5.5 Manufacturers' name or trade mark.
- 5.6 Year of manufacture.
- 5.7 Country of origin.

6.0 TESTING AND INSPECTION:

6.1 General:

All expulsion fuse cutouts shall be tested in accordance with the latest standards and as specified herein.

The supplier/vendor shall provide acceptable type test certificates for his fuse cutouts. Two certified copies of the test reports shall be submitted to the MOE for approval. No equipment shall be shipped until approval of the test reports has been given by MOE.

6.2 Type tests:

The expulsion fuse cutouts offered shall meet the type test requirements of the standards given below:

6.2.1 Dielectric tests to IEC 60282-2 (clause 11).

- Power frequency withstand (1 minute dry and wet)
- Impulse withstand (1.2 x 50 μ sec).

6.2.2 Interrupting capacity to IEC 60282-2, clause 13.

6.2.3 Radio interference test to IEC 60437.

6.2.4 Temperature rise tests to IEC 60282-2, clause 12.

6.2.5 Pollution performance test as per IEC 60507.

- Salt spray corrosion performance tests for 1000 hours.
- Solid layer pollution test.

6.2.6 Expendable caps shall be subject to a static relief pressure test to ANSI C 37.42, clause 2.2.7.

6.2.7 Load break tests to ANSI C 37, 41, clause 7.

Tests shall be made with the manufacturers recommended portable load break device.

6.3 Routine tests:

Supplier shall provide detail of the routine tests, which will be performed on the expulsion fuse cutouts with the minimum requirements listed as follows:

6.3.1 Insulator tests.

6.3.2 Power frequency reference or low current.

6.4 Inspection:

MOE may wish to witness tests or visit the factory during manufacture of any or all items covered by this specification. Accordingly the supplier shall give MOE adequate notice of manufacturing and test schedules. MOE may require certificates and data from the manufacturer/supplier on all pertinent aspects of the manufacturing process.

7.0 PACKING AND SHIPMENT:

Each expulsion fuse cutout shall be packed individually in a strong non returnable wooden crate/ card board box in such manner to prevent damage to components during transportation and handling up to installation site. Packing shall be designed to prevent entry of dust, ingress of moisture and other foreign materials. The mounting bracket, where required, shall be packed separately. Each container shall have the following information stenciled on it in English and /or Arabic.

- Manufacture's name.
- Country of origin.
- MOE item number.
- MOE purchase order number.
- Weight in kilogram.
- Handling instruction.
- Voltage and current rating.

7.1 Supplier shall contact material department for additional packing, handling and shipment instructions as applicable.

7.2 Packing note in Arabic and/or English shall be included in each case giving description of goods packed.

7.3 Expulsion fuse cutouts shall not be packed in any organic material.

8.0 GUARANTEE:

8.1 Vendor shall guarantee the expulsion fuse cutouts against all the defects arising out of faulty design, workmanship or defective material for a period of one (1) year from the date of installation or two (2) years from the date of delivery, unless and otherwise specified in tender documents.

8.2 If no exception/deviations are taken to this specification and no list of deviations is submitted, it shall be deemed that, in every respect, the offered expulsion fuse cutouts and their accessories conform to this specification.

9.0 TECHNICAL DATA:

9.1 The vendor shall complete and return one copy of the attached data Schedule with quotation. In addition to data Schedule, clause by clause compliance to this specification shall be confirmed/ submitted.

9.2 Detail dimensional drawing of the expulsion fuse cutout and mounting arrangements shall be submitted.

9.3 The supplier shall provide literature describing field experience under similar service conditions.

9.4 A reference sale list shall be included. This shall detail the quantities sold, name and address of users, the number of years in service in each case. The literature shall show at least 10 years service in each environment.

9.5 Type test certificates.

9.6 Submittal required following award of contract, are given below:

- Manufacturing schedule, progress report and test schedule.
- Test report.

TECHNICAL DATA SCHEDULE
24 kV EXPULSION FUSE CUTOUT
(sheet 1 of 3)

S.No.	DESCRIPTION.	UNIT.	MOE SPECIFIED VALUES.	VENDOR PROPOSED VALUES.
1	System voltage	kV	24	
2	Max design voltage	kV	24	
3	Continuous current capacity	A	100	
4	Interrupting current (symmetrical)	kA	8	
5	BIL at altitude ≤ 1000 m	kV	145	
6	BIL at altitude > 1000 m	kV	145	
7	Total minimum creepage distance	mm		
8	Power frequency with stand 1 min dry and wet: To earth and between poles. Across the isolating distances.	kV	50 60	
9	Impulse (1.2 μ sec) To earth and between poles. Across the isolating distances.	kV	145 145	
10	Max radio interference voltage	μ V	250	
11	Ambient temperature during temperature rise tests	$^{\circ}$ C	*	
12	Temperature rise of contacts	$^{\circ}$ C	*	
13	Temperature rise of terminals	$^{\circ}$ C	*	
14	Material of support insulators		Porcelain	
15	Color of the insulator		Glazed brown / grey	
16	Manufacturer of insulator a) Main insulator b) Stand off insulator			
17	Type of main contacts material		Copper	

* To be specified in tender documents.

TECHNICAL DATA SCHEDULE
33 kV EXPULSION FUSE CUTOUT
(sheet 2 of 3)

S.No.	DESCRIPTION	UNIT	MOE SPECIFIED VALUES	VENDOR PROPOSED VALUES
1	System voltage	kV	33	
2	Max design voltage	kV	36	
3	Continuous current capacity	A	100 *	
4	Interrupting current (symmetrical)	kA	8	
5	BIL at altitude ≤ 1000 m	kV	170	
6	BIL at altitude > 1000 m	kV	200	
7	Total minimum creepage distance	mm	825, 1320 *	
8	Power frequency with stand 1 min dry and wet: To earth and between poles. Across the isolating distances.	kV	70 80	
9	Impulse (1.2 μ sec). To earth and between poles. Across the isolating distances.	kV	170 200	
10	Max radio interference voltage	μ V	650	
11	Ambient temperature during temperature rise tests	$^{\circ}$ C	*	
12	Temperature rise of contacts	$^{\circ}$ C	*	
13	Temperature rise of terminals	$^{\circ}$ C	*	
14	Material of support insulators		Porcelain	
15	Color of the insulator		Glazed brown/ grey	
16	Manufacturer of insulator a) Main insulator b) Stand off insulator			
17	Type of main contacts material		Copper	

* To be specified in tender documents.

TECHNICAL DATA SCHEDULE
24, 33 kV EXPULSION FUSE CUTOUT
(sheet 3 of 3)

S.No.	DESCRIPTION	UNIT	MOE SPECIFIED VALUES	VENDOR PROPOSED VALUES
18	Fuse cut-out with single or stand-off insulator NEMA brackets		Required	
19	Cutout suitable for removable button head fuse link		Yes/ no	
20	All assemblies potted into the porcelain		Required	
21	Angle of the fuse insulator to the vertical		15° - 20°	
22	Shed to be incorporated into upper contact assembly		Required.	
23	All current carrying parts of copper or copper alloy		Required.	
24	Conductors terminals tin plated		Required.	
25	Contacts silver clad		Required.	
26	All ferrous components galvanized		Required.	
27	Load break hooks fitting		Required.	
28	Arc interruption assisted by a spring operated flipper		Required.	
29	The protection of fuse link from mechanical shock by latching of toggle mechanism		Required.	
30	Non expendable type fuse cap		Required.	
31	The fuse tube marked with manufacturer, model continuous and interrupting current rating,, rated voltage and date of manufacture		Required.	
32	Routine tests carried out on 100% of the offered items		Required.	
33	Type test certificates included in the tender along with complete descriptive literature		Required.	

COMMISSION of ELECTRICITY
Planning and Studies division
Baghdad – IRAQ

Specification NO.	D-09
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Technical Specification
OF
Outdoor L.V switchgear
Pole - mounted

REVISION	Year 2012	2016
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Outdoor L.V. Switchgear pole - mounted

1.SCOPE OF THE TENDER :

The tender includes ,design ,manufacture ,testing ,supply, packing ,shipping and delivery of circuit breaker's cabinet, and all necessary fittings for connecting cables ,accessories ,spare parts ,tools and handling equipment .etc. for 100KVA ,250KVA,400KVA

Transformer KVA	100KVA	250KVA	400KVA
C.B rated current	200 A	250A	400A

The switchgear panel composed of:-

- a- Sheet steel construction cabinet not to be less than 2 mm thickness.
 - b- Three pole 416/240 V, 50HZ , one circuit breaker for outgoing feeder control equipped with parallel or sleeve type cable connection on both sides for single core PVC insulated copper of 95 and 150 sq.mm . The C.B to be designed with thermal or micro logic O/C protection (80 -100)%, and magnetic short circuit shall be between 5-10 times rated current. The rated ultimate breaking capacity (Icu) and rated service breaking capacity (Ics) of C.B should be 35KA for both. The current capacity of C.B should be minimum 80% of its rated current at 55C.
 - c- The panel shall have hinged door type with tow screws for locking (the bolts and nuts should be non-removable type) with provision namely
 - c-1 Flap opening for circuit breaker (ON/OFF) operation.
 - c-2 Bolted type cover for the C.B. cable connections.
 - c-3 the cabinet shall be provided with mounting bracket.
 - d- copper bus bar of suitable cross section area according to C.B current rating for connect incoming and outgoing cables and ambient temperature 55C
- Note :The C.B should be provided with free contacts for external tripping.

1- GENERAL REQUIREMENTS :

The equipments shall be of first class quality and designed for continuous satisfactory operation as continuity of supply , is of prime consideration the design shall allow all necessary precautions for the safety of the operation and maintenance personnel. All, equipment shall operate satisfactorily under variations of load ,voltage and short circuit or other conditions which may occur on the system provided that these variations are within the assigned ratings the apparatus .

All the equipments shall be designed to obviate the risk of accidental short circuit or damage due to vermin's .

All openings for ventilation must have wire mesh screen .

The equipments used shall be suitable for the following climatic conditions prevailing at site .

2-1 Ambient temperature:

Highest maximum (in the shade)	55 deg.C. for about 6. Hours aday
Lowest minimum	-10 deg.C.
Maximum yearly average	+ 30 deg .C.
Maximum daily average	+ 40 deg .C.

2-2 Sun Temperature

Black objects under direct sunshine may attain a temperature of 80 deg.C.

2-3 Air humidity :

Maximum	92% at 40 deg. C.
Minimum	12%
Yearly average	44%

2-4 Altitudes

From sea level up to (1000m)

2-5 Sand storm:

The equipments are subjected to strong and frequent sand storms. Adequate precaution must be taken to cater for this.

2-6 Condensation:

Enclosed compartments shall have interior surfaces treated with approved materials and shall be adequately ventilated to prevent condensation.

The interior surfaces shall be treated and approved manner to prevent mould growth. Such treatment should in no way interfere with the satisfactory operation of the equipment electrically or mechanically.

3- Technical requirement

3-1 System Data:

Nominal voltage.....	416/240 Volts (+4%) (- 10%)
Frequency.....	. 50 HZ.
System	3 phase,4-wire with neutral solidly earthed.
Short circuit level	according to the transformer capacity

3-2 Standards:

All the equipments and accessories shall be in accordance with the latest issue of the international Electro – technical commission (I.E.C) specification.

Where these specifications are incomplete or not yet published, then the National standards of tender's country shall be considered subject to our approval.

4- SWITCHGEAR

The low voltage switchgear are intended to be used on the L.V side of the 11/0.416KV 400KVA 250KVA and 100 KVA transformer. The switchgear shall be of out door type, pole mounted. The cabinet should be of sheet steel construction not less than 2mm thickness with electro-static and thermal painting. The switchgear shall be provided double roof with space for maximum ventilation (Sun-shield to extend from all sides by 10cm except rear). With louvers covered with mesh wire screen. The circuit breaker shall be accommodated in a panel. Please refer to scope of operation of circuit breaker to be from outside after opening the Flap, following points are to be equipped with:

a-Sleeves type connection for all cables (cable thimbles with bolts, nuts and washer).

b- Cabinet supporting brackets to be provided.

The cabinet is to be water-proof and entirely protected against the danger of vermin and dust, the degree of protection is to be IP55. The degree of protection is to be IP34 for ventilation inlets. The synthetic material should be resistant to the atmospheric conditions of para . 2-1 to 2-6 and immune from corrosive actions of chemicals and fire proof. The cabinet should be provided with the facility of earth connection.

c-cable glands suitable for incoming and outgoing cables and also suitable with the degree of protection of the cabinet

d- Name plate

The switchgear shall be incorporated with the following:-

4-1 Circuit Breaker:

The Circuit breaker shall comply with IEC 947-2 category B and shall be air break , molded case type of the ratings specified in the schedule attached herewith. The operating machine shall be of trip free type.

. A mechanical ON/OFF indication for C.B. position is to be provided. Provision for pad locking the door or the C.B. position is to be provided and the operating handle to be engaged when the door is closed. cabinet serial No. from origin manufacturer is required.

4-2 Selectivity:

The 11KV side of the transformer is protected by means of H.R.C current limiting fuses.

The tendered will have to insure that the protection setting of the circuit breaker will make it possible to obtain selective tripping between the circuit breaker and the fuses on the 11KV sides. The selective tripping will have to be maintained throughout the ambient temperature variation.

The successful tender will be supplied with type, rating and the time/current characteristics of the fuses mounted on the 11KV side in order to insure selectivity of tripping. A mechanical (ON/OFF) indication for C.B position is to be provided.

5- DRAWING AND INSTRUCTION BOOKS

5-1The following documents shall be submitted in three copies with the tender documents in the English language.

Technical literature giving full details of the switchgear offered also out line drawings with dimensions showing top, front and side elevation.

Technical literature giving full description of C.B offered.

5-2 The document to be furnished by the successful tenderer in the English language should includes three copies of the following drawings within two months from the date of the order.

Schedule of the anticipated shipping dates.

Installation drawings.

Outlined drawings & sectional elevation.

All instruction for maintenance, testing and commissioning.

Renewal part list sufficient for 5 years operation.

NOTE

It must be noted that all drawings are subjected to approval by us before manufacturing.

6- PACKING

The supplier will pack each set of the panels or protect the goods in the most appropriate manner. He will be responsible for any loss or damage rising from careless packing or protection up to the place of final destination after completion of the inspections and tests at the factory, each item shall be packed for export shipment. All parts provided for shipping purposes only and which are to be removed at the time of erection shall be consequently tagged.

The method of packing shall be such as to protect all item against excessive corrosion or dampness, and shall afford adequate protection against breakage or other injury, or loss due to breakage of cases or crates from the time the items leaves until finally installed at the substation during the apparatus will travel by rail by along sea voyage again by rail or truck to the site of the substation.

The apparatus will also undoubtedly stand on whares and in the open during and in between periods of transportation and will thereby be exposed to heavy rains, hot sun, humid climate and sudden changes of temperature.

Owing to the numerous handlings, the container should be very strong. Also extra ordinary care should be given to the packing of the equipment and especially the items having installing material to prevent the injury due to moisture from sources external to the packing or from excessive condensation with the packing.

7- TESTS

7-1 Inspection:

The material shall be subject to inspection by our inspectors at any time during manufacture. The manufacture shall provide all inspection facilities for the side inspection and testing. All testing and inspection shall be made at the place of manufacture. The inspector shall have the right of rejecting any part or all of the material at any time during manufacture if it dose not meet with the requirements of this specification in all particulars. He shall have the right of overseeing the packing and shipping of all materials to be supplied.

7-2 Tests at Manufacturer Work:

tests requirements at manufacturer work shall be as follows:-

a- Type test :

Type test certificates to prove the general design of the equipment must be submitted by the tenderer.

The certificates are to be for tests which have been carried out on identical equipment. These tests are in general those detailed in the relevant IEC which pertain to the equipment being tested.

b- Routine test

the routine test shall be carried out of each of the following equipment according to IEC recommendation:

a-Switchgear – Enclosure.

b-Circuit breaker.

8- PAINTING

Electro-static and thermal painting.

NOTE: The tenderer should be submit all technical information according to IEC 947-2 and fill the data which is required in the attached sheet.

Attach sheet

Items	unit	200A C.B	250A C.B	400A C.B
Degree of protection According to IEC 529				
Ambient temperature -Storage(min-max) -operation(min-max) In open air In enclosure	C			
Tightening torque	N.M			
Rated operational voltage According IEC 947-2	V			
Rated insulation voltage According IEC 947-2	V			
Rated impulse withstand voltage According IEC 947-2	KV			
Mechanical durability (C.O: closing ,opening)	C.O			
Electrical durability (C.O: closing ,opening)	C.O			
Duty class	C.O/h			
Rated ultimate short-circuit breaking capacity(Icu)	KA			
Rated service short-circuit breaking capacity (Ics)	KA			
Rated short-circuit making capacity (peak value)				
Rated short –time withstand current(Icw)	Icw(1s) KA			
	Icw(3s) KA			

**Ministry of Electricity
Planning and Studies Office
Baghdad – Iraq**

Specification No.	D-24
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**TECHNICAL SPECIFICATION OF
OVERHEAD LINE PORCELAIN
INSULATORS**

Revision	Year 2015
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1.0 SCOPE

This Specification specifies the minimum technical requirements for design, materials, manufacturing, testing, and performance of the following porcelain insulators:

- 1.1 L.T shackles insulators.
- 1.2 15 kV brown glazed porcelain pin insulator with spindle.
- 1.3 15 kV disc insulator with tension string.
- 1.4 36 kV brown glazed porcelain pin insulator with spindle.

These insulators are intended to be used in the overhead line distribution system of (MOE).

2.0 GENERAL REQUIREMENTS

The equipment shall be of first class quality and designed for continues satisfactory operation as continuity of supplies of prime importance. The materials shall be suitable for the following climatic conditions prevailing at site:

2.1 Ambient temperature:

- Highest maximum (in the shade) 55 C° for about 6 hours a day
- Lowest minimum - 10 C°
- Max. Yearly average + 30 C°
- Max. Daily average + 30 C°

2.2 Temperature under sun:

Black object under direct Sun shine attain a temperature of + 80 C°

2.3 Air humidity:

Maximum	92% at 40 C°
Minimum	12%
Yearly average	44%

2.4 Altitudes:

From sea level up to 1000 m

2.5 Dust storms:

The materials are subjected to strong & frequent dust storms.

3.0 APPLICABLE CODES AND STANDARDS

The latest revision of the following codes and standards shall be applicable for the equipment/material covered in this specification. In case of any deviation, the vendor/ manufacturer may propose equipment/ material, conforming to an alternate code or standard. However, the provision of MOE standards shall supersede the provisions of these alternate standards in case of any difference:

IEC

International Electrotechnical Commission

IEC 60168	Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000V.
IEC 60273	Characteristics of indoor and outdoor post insulators and post insulator units for systems with nominal voltages greater than 1000V.
IEC 60383	Tests on insulators of ceramic material or glass for overhead lines with a nominal voltage greater than 1000V.
IEC 60437	Radio interference test on high voltage insulators.

IEC 60471	Characteristics of clevis and tongue couplings of string insulator units.
IEC 60507	Artificial pollution tests on high voltage insulators to be used on AC systems.
IEC 60575	Thermal – Mechanical performance test and mechanical performance test on string insulator units.
IEC60720	Characteristics of line post insulators.

ANSI **American National Standards Institute**

ANSI C29.1	Test methods for electrical power insulators.
ANSI C29.2	Wet process porcelain and toughened glass insulators- suspension type.
ANSI C29.3	Wet process porcelain insulators (Spool type).
ANSI C29.7	Wet process porcelain insulators (High voltage line- post type).
ANSI C29.9	Wet process porcelain insulators (Apparatus, post type).

ASTM **American Society for Testing & Materials**

ASTM- A153	Standard specification for Zinc coating (Hot Dip) on iron and steel hardware.
ASTM-C151	Test method for Autoclave expansion of Portland cement.

BS **British Standards Institute**

BS 137	Insulators of ceramic material or glass for overhead lines with a nominal voltage greater than 1000V.
BS 3288	Insulators and conductor fittings for overhead power lines (Parts 1&2).
BS 729	Galvanizing.

4.0 MV, LV INSULATORS AND ACCESSORIES SPECIFICATIONS

4.1 15 kV and 36 kV, 50 HZ brown glazes porcelain type insulators. The pin hole thread is of the cemented zinc thimble type. The top grooves of the insulator shall be suitable for bare conductor ACSR 120/20 mm². Overall diameter (15.5) mm for 15 kV, ACSR 210/35 mm². Overall diameter (20.3) mm for 36 kV.

4.2 Galvanized steel spindles for 15 kV and 36 kV. The minimum height shall not be less than 125 mm and 18.5 mm in diameter. Having tapered body and 75 mm threaded and out of 150 mm shank. The spindles shall be supplied complete with spring washers and nuts. As it illustrated in table (1 & 2) attached.

4.3 LV (1200 V) brown glazes shackle insulators having conductor groove of 15mm.

4.4 D-bracket & accessories for LV insulators complete with all necessary bolts (16 x 120), nuts and washers.

4.5 Hexagon head deck bolt (16 x 180) to be used with D-bracket.

4.6 15 KV disc insulator brown glazed porcelain ball and socket type coupling suitable combined mechanical and electrical strength.

4.7 Technical specification of disc insulator accessories

4.7.1 Ball eyes

The ball eye shall be manufactured from forging quality medium carbon and hot dip galvanized according to (BS-729) the ball dimension shall be (16mm) the minimum failing load shall be (75kn).

4.7.2 Socket eyes

The socket eye shall be manufactured from forging quality medium carbon steel and hot dip galvanized according to (BS-729) the socket dimension shall be suitable for (16mm) ball eye diameter the minimum failing load shall be (75kn). The security clip shall be of phosphor bronze material and the split pins shall be stainless steel.

4.7.3 Strain & suspension clamps

4.7.3.1 Strain clamp U-bolted type suitable for (AAC & ACSR) conductors overall diameter (12.5-18.0) mm with aluminum tape. The material of clamp should be cast iron and galvanized according to (BS-729).

The connecting of conductor with clamp should be by (2-3) U-bolts and nuts manufactured from galvanized mild steel minimum ultimate strength (75kn). The conductor seating area shall be free from any roughness and burrs. The outer and inner edges shall be rounded to avoid any damage on the conductor after assembly the slip strength of the clamp should be (95%) of the breaking load of conductor or (43kn).

4.7.3.2 Strain clamp U-bolted type suitable for (ACSR) conductors overall diameter (15.5-23.0) mm with the same specification of item (5.3.1) above but the minimum ultimate strength (90kn). And slip strength of clamp (68kn).

4.7.3.3 Suspension clamp U-bolted type suitable for (ACSR) conductors with overall diameter (15.5-23.0) mm. the material of clamp body and keepers are malleable iron hot dip galvanized according to (BS-729) cotter pins should be bronze. The connecting of conductor with clamp should be by (2) U-bolts and nuts manufactured of the hot dip galvanized mild steel the minimum ultimate strength of clamp (40kn). The conductor strength area shall be free from any roughness and burrs. The outer and inner edge shall be rounded to avoid any damage on the conductor after assembly. The slip strength of the clamp should be (20%) of the breaking load of conductor or (15kn).

Note:

1. The dimensions, electrical and mechanical withstand specification of (15 and 36) kV pin insulators, (1.2 kV) shackle insulator and (15 kV) disc insulator is as stated in table (3).
2. Samples are required with the offers.

5.0 Marking

- 5.1 Each insulator shall bear a marking as per ANSI or IEC Standards, Identifying the following (English):
 - a. Manufacturer name.
 - b. Year of manufacturing.
 - c. Designation number.
 - d. Cantilever strength (Combined M&E strength suspension insulator).
 - e. Country of origin.
- 5.2 Crate Marking (English and/or Arabic):
 - a. Nominal System voltage.
 - b. Type of insulator.
 - c. MOE purchase order number / contract number.
 - d. MOE Item number.
 - e. Weight, Kg.
 - f. Manufacturer name / Country of origin.

6.0 TESTING AND INSPECTION

All test results shall be provided for review and acceptance by MOE.

6.1 Type Tests

- 6.1.1 All type tests prescribed in the relevant IEC or equivalent ANSI standards shall be performed on the representative unit or on the first unit of every new design or rating to be supplied to MOE.
- 6.1.2 The certified test reports of type tests performed on a unit of identical design and rating may be submitted to MOE for review and approval during bidding stage.
- 6.1.3 In addition to the above IEC or ANSI type test requirements, the following type tests shall be carried out for suspension insulators:
 - a. Thermal–Mechanical performance test on suspension insulator units in accordance with IEC 60575.
 - b. Autoclave Expansion Test for Portland cement - The soundness of Portland cement to be used as the bonding agent for wet- process aluminous porcelain insulators shall be tested in accordance with the ASTM C151. Ten (10) samples of cement for the test specimen shall be selected at random from the batch to be used for insulators. The bars prepared from neat cement when subjected to high pressure steam at 2 ± 0.07 Mpa for three hours at 216° C shall not show expansion of more than 0.12 percent. The expansion of cement more than 0.12 percent in the test shall be the cause for rejection of the whole batch of cement.

6.2 Routine Tests

6.2.1 All routine tests prescribed in the relevant IEC or equivalent ANSI standards shall be performed on all units prior to delivery to MOE.

6.2.2 Electrical routine tests shall be carried out on each stand off insulator:

- a. The ultrasonic test shall be performed on solid core and the puncture test shall be performed on hollow core porcelain insulators.
- b. Routine flashover test shall also be performed on hollow core porcelain insulators.

6.4 Special Tests

The pollution test, as an option shall be performed in accordance with IEC 60507, if requested by MOE prior to delivery.

6.5 Inspection

MOE may wish to witness tests or visit the factory during manufacture of any or all Items covered by this specification. Accordingly the supplier shall be give the purchaser adequate notice of manufacturing program and test to be witnessed. MOE may require certificates and data from the manufacturer/supplier on all pertinent aspects of the manufacturing process.

7.0 PACKING AND SHIPMENT

Packing and shipping of the insulators shall conform the following:

- a. All parts shall be carefully packed for transport in such a manner that they are protected against mechanical damage and climatic conditions during transportation or storage.
- b. Suppliers shall contact Materials Management Department for additional packing, handling and shipment instructions, as applicable.

8.0 GUARANTEE

8.1 Supplier shall guarantee the insulators against all defects arising out of faulty design, workmanship, or defective material for a period of two (2) years from date of delivery.

8.2 If no exceptions are taken to this specification and no list of deviation is submitted, it shall be deemed that in every respect the offered insulators conform to this specification. MOE interpretation of this specification shall be accepted.

9.0 SUBMITTALS

9.1 Submittals required with tender:

- 9.1.1 The vendor shall complete and return one copy of the attached technical data schedule with quotation.
- 9.1.2 Detailed dimensional drawing of insulators.
- 9.1.3 Type test certificates.
- 9.1.4 Catalogues.

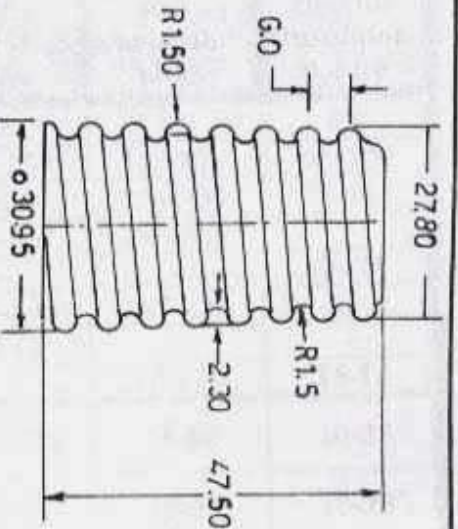
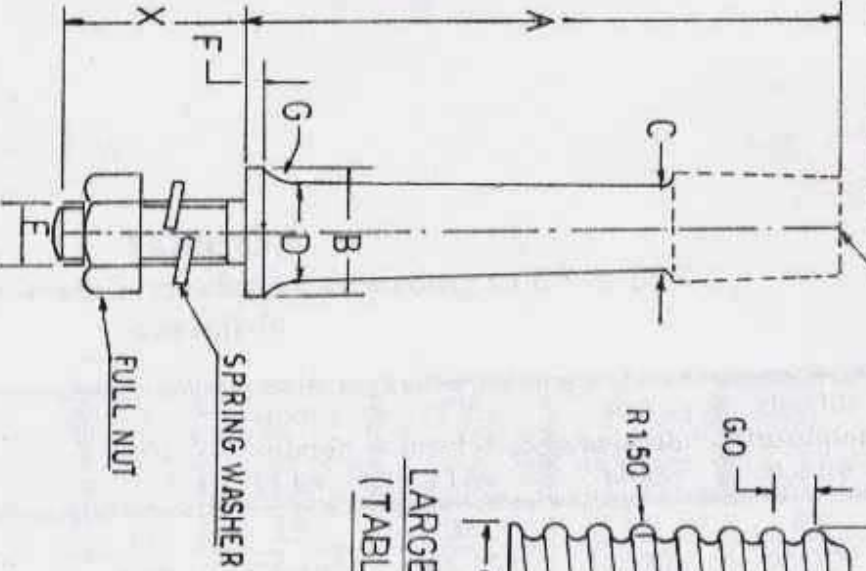
9.2 Submittals required following award of contract are given below.

- 9.2.1 Manufacturing schedule, progress report and test schedule.
- 9.2.2 Test reports

Table (3)
Specifications of porcelain insulators according to BS & IEC standards

shackle insulator 0.4 kV	disc insulator 11 kV	pin insulator 33 kV	pin insulator 11 kV	unit	type of insulator		
0.6	15	36	15	kV	highest system voltage		
65-100	145-170	203-250	135-160	mm	total high " H "		
75-115	255-280	≥280	140-175	mm	total diameter " D "		
-	290-350	580-685	270-320	mm	total creepage distance		
66-75	-	-	-	mm	leakage distance		
-	165-230	300-335	120-140	mm	protected creepage distance (90°)		
-	-	10-12	10-12	kn	cantilever strength (min)		
15-16	70-120	-	-	kn	combined Electro mechanical strength		
20-35	75-80	110-130	70-80	kV	flashover voltage	one minute dry	
10-25	45-50	85-95	40-55	kV		power frequency wet	
-	115-130	205-210	105-115	kvp		impulse + ve	
-	120-135	225-250	110-140	kvp		- ve	
≥23	70-75	100-110	65-75	kV	dry	withstand voltage	one minute power frequency
≥10	40-45	80-90	35-50	kV	wet		impulse
-	110-120	180-200	95-105	kvp	+ ve		
-	115-125	190-220	105-120	kvp	- ve		
power frequency puncture voltage dry F.O.V			kV	105-120	200-210	110-130	1.3 actual
-	9-18	≥ 29	≥ 9	kV		visible discharge voltage	
0.6-1.0	5-8	7.5-9.5	1.8-2.5	kg		net weight (approx.)	
-	16	-	-	mm		ball and socket size	

LARGE STEEL HEAD



LARGE STEEL HEAD
(TABLE-2)

- NOTES:-**
1. DIMENSIONS X TO BE 150 mm SCREWED 10 mm
 2. ALL DIMENSIONS ARE AFTER HOT DIP GALVANIZING GALVANIZING TEST TO CONFORM TO B.S: 779
 3. 15% MAXIMUM DEFLECTION PERMISSIBLE AT A MINIMUM SPECIFIED FAILING LOAD
 4. PIN WILL BE SUPPLIED WITH SPRING WASHER & FULL NUT
 5. MASS OF ZINC COATING (MIN) 510 gm/m² (85u)

ALSO PASS 4*1 MINUTE DIP TEST

MINIMUM FAILING LOAD	REF NO	A	B MIN	C	D MIN	E	F	G RAD	X
10 kN	31	305	63	27	40	22	6	16	150

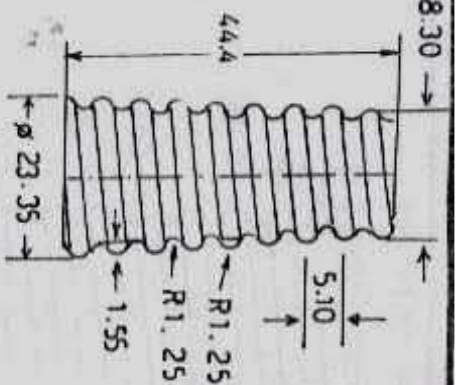
STATE COMPANY OF ELECTRICITY DISTRIBUTION
FOR THE MIDDLE

LARGE STEEL HEAD SPINDLE
(B.S: 3288 PART-11)

ALL DIMENSIONS IN. mm	DRAWN MAY
SCALE : N.T.S	CHECKED KH-S-
DATE : 1-8-2001	

NOTES:-

1. DIMENSIONS 'X' TO BE 150 mm. SCREWED 80 mm.
2. MATERIAL:- FORGED STEEL.
3. ALL DIMENSIONS ARE AFTER HOT DIP GALVANIZING. GALVANIZING TO CONFORM TO BS. 729.
4. PIN WILL BE SUPPLIED WITH SPRING WASHER & FULL NUT.
5. 15% MAXIMUM DEFLECTION PERMISSIBLE AT A MINIMUM SPECIFIED FAILING LOAD.
6. MASS OF ZINC COATING 9 mm Ø 610 gm/m² (85u) ALSO PASS 4x1 MINUTE DIP TEST.



SMALL STEEL HEAD.

(TABLE-1)

MINIMUM FAILING LOAD	REF NO.	A.	B. MIN	C.	D. MIN	E.	F.	G. RED.	X
10KN.	23	165	43	24	31	M18	6	13	150

STATE COMPANY OF ELECTRICITY DISTRIBUTION FOR THE MIDDLE

SMALL STEEL HEAD SPINDLE (B.S 3288 PART II)

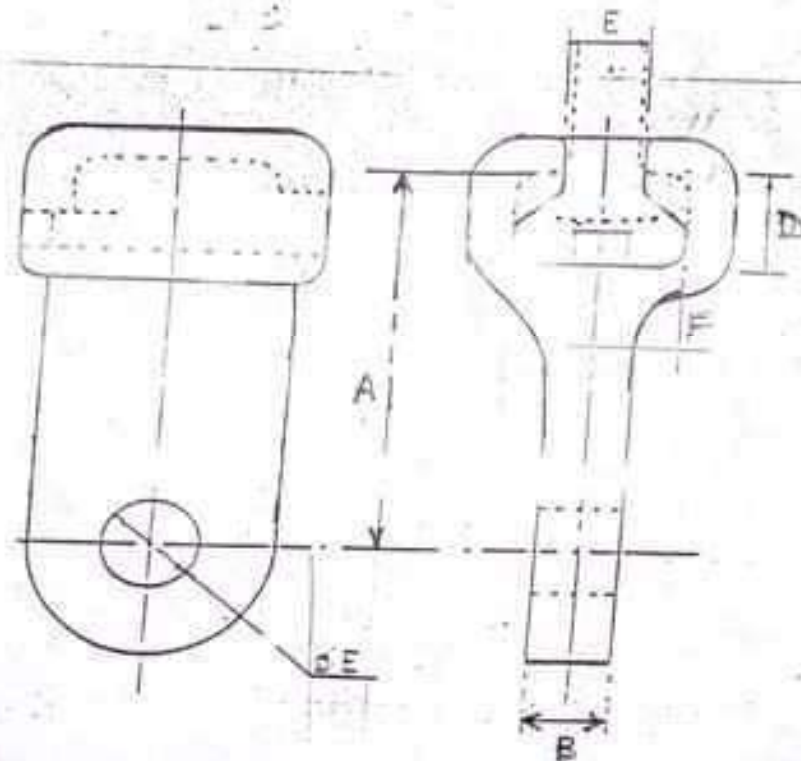
ALL DIMENTION IN mm

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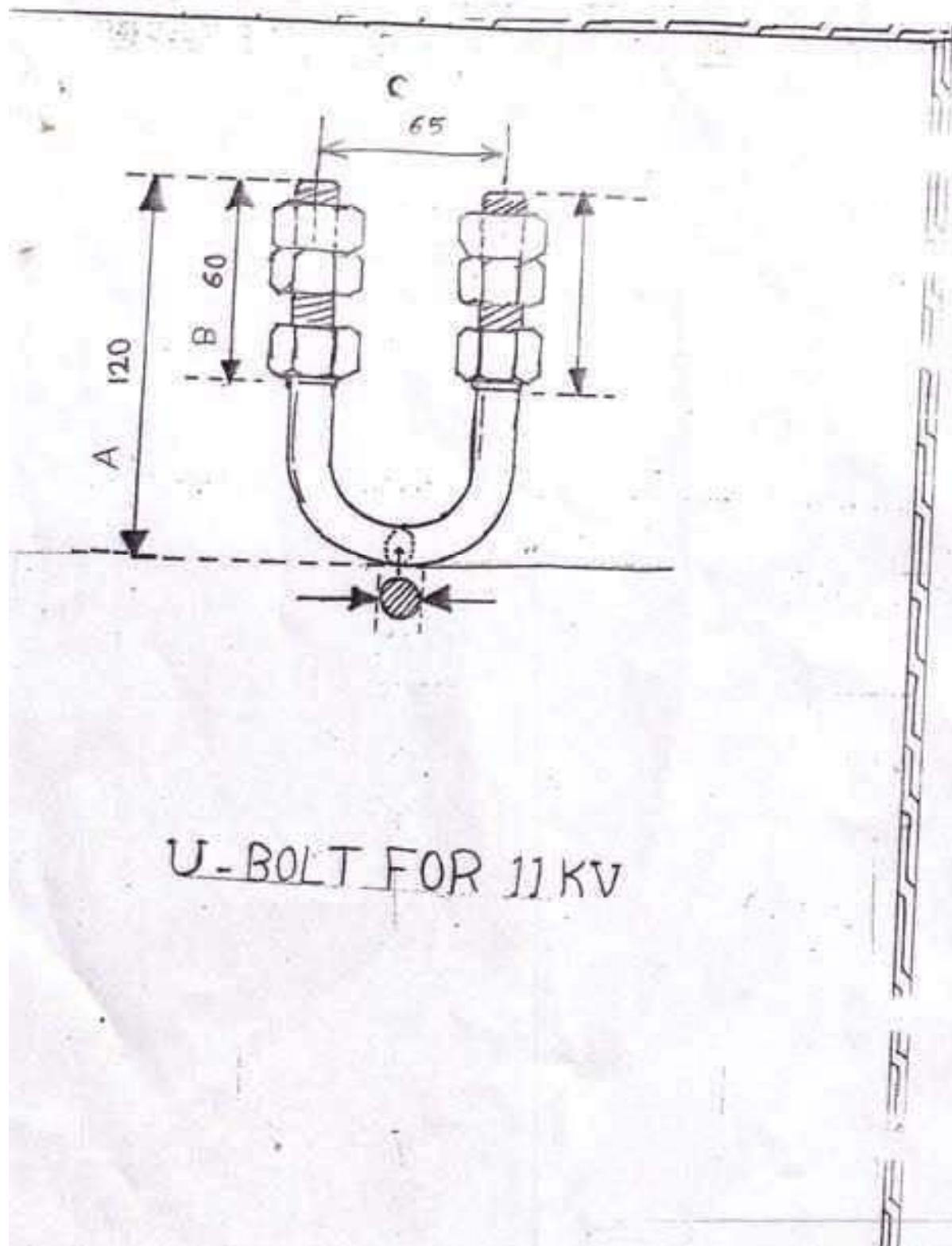
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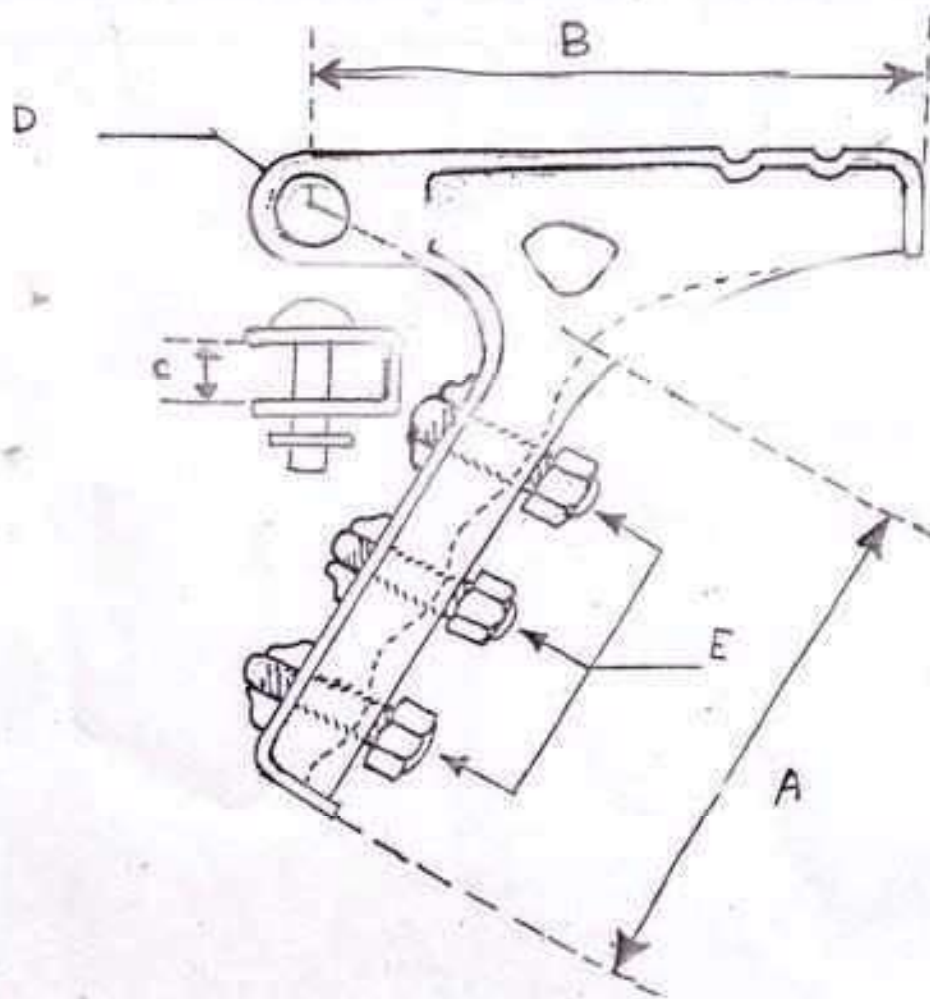
CHECKED : K. SOLAKA

DATE : 1-8-2001



Socket Eye





Tension clamp

Specifications For Cable Terminals

Cable terminals connectors used to join a copper conductor to a copper stud. This electrolytic copper lug shall be of tubular type, tin coated 3 – 4 microns. The lug shall be made of a barrel intend to receive the conductor.

The barrel shall be suitable for intend compression by compression tools.

The following sizes and quantities are required :-

NO.	SPECIFICATION
1-	For copper conductor of 50mm ² Cross-section
2-	For copper conductor of 70mm ² Cross-section
3-	For copper conductor of 95mm ² Cross-section
4-	For copper conductor of 120mm ² Cross-section
5-	For copper conductor of 150mm ² Cross-section
6-	For copper conductor of 200mm ² Cross-section

COMMISSION of ELECTRICITY
Planning and Studies division
Baghdad – IRAQ

Specification NO.	D-47
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Technical Specification

OF

ALMINUM – BARE WIRES

REVISION	Year 2001		
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STATE COMPANY FOR ELECTRICITY DISTRIBUTION FOR MIDDLE

AL- BARE WIRES

1. SCOPE OF THE TENDER: -

This tender includes for the manufacturing, testing, packing, and shipping delivery exworks, FOP & CIF of bare conductors.

2. GENERAL REQUIREMENT: -

The materials shall be of first class quality and designed for continuous satisfactory operation as continuity of supply is of prime importance and to operate satisfactorily under variation of load voltage and short circuit or other conditions which may occur on the system provided that these variations are within the assigned rating of the apparatus. The materials used shall be suitable for the following climatic conditions.

2-1 Ambient temperature:

Highest maximum in the shade 50C° for about 6 hours a day.

Lowest minimum (-10) C°.

Maximum yearly average (+ 30) C°.

Maximum daily average (+ 40) C°.

2-2 Sun temperature:

Black objects under direct sunshine attain a temperature of 75 C°.

2-3 Air humidity:

Maximum	92% at 40C°
Minimum	12%
Yearly average	44%

2-4 Altitudes:

From sea level up to (1000 m).

3. TECHNICAL REQUIREMENT:

3-1 STANDARDS:

3.1.1. The bare aluminum conductor shall be in accordance with the latest issues DIN (48201) and IEC (207) publication.

3.1.2. The aluminum conductors, steel reinforced shall be in accordance with the latest issues of the DIN (48204) & IEC (209) publication.

3.1.3. The copper conductors shall be in accordance with the latest issues of BSS 125.

- 3-2 **DEVIATIONS:**
The tenderer shall particularly mention in his tender all deviations of his offer from the specifications described in tender documents.

4. GENERAL CONDUCTOR CHARACTERISTICS:

- 4-1 The bare copper conductor should be composed of stranded hard drawn electrolytic copper conductor of 99.97% purity.
- 4-2 The bare aluminum conductor should be composed of stranded hard drawn aluminum.
- 4-3 The A.C.S.R conductor shall have bare stranded hard drawn aluminum conductor's steel reinforced. The conductors shall be internally protected with appropriate grease suitable for a working temperature of 80C°.
- 4-4 **Packing**
The required conductor lengths are to be supplied on seaworthy wooden drums of lengths as specified in item 5.
The drums should be steel reinforced radically and round the borehole after winding the conductor on the drum, it should be covered with suitable stand. Wooden lagging the overall construction must be of robust. Quintile to withstand rough handling.
The drum should have a nameplate stating the following in both English and Arabic languages.
- a- Type & size of conductor.
- b- Net weight & gross weight.
- c- Total length of conductor on the drum.
- d- Our purchase order number.

5. TYPE OF CONDUCTOR:

5-1 Copper conductor

For this conductor, the applicable paragraphs of article 4 are: 4.1 & 4.4

The sizes of conductor required are as follows:

- ❖ 16 mm², conductor details 7/1.75 mm & 3000 m \pm 2% per drum.
- ❖ 25 mm², conductor details 19/1.32 mm & 3000 m \pm 2% per drum.
- ❖ 50 mm², conductor details 19/1.8 mm & 2000 m \pm 2% per drum.
- ❖ 70 mm², conductor details 19/2.1 mm & 2000 m \pm 2% per drum.
- ❖ 95 mm², conductor details 19/2.5 mm & 1500 m \pm 2% per drum.

5-2 AL – Aluminum conductor - AAC

For this conductor, the applicable paragraphs of article 4 are: 4.2 & 4.4

The sizes of conductor required are as follows:

- ❖ 95 mm² 19/2.5 mm & 2000 m \pm 2% per drum.
- ❖ 70 mm² 19/2.1 mm & 3000 m \pm 2% per drum.
- ❖ 50 mm² 19/1.8 mm & 3000 m \pm 2% per drum.
- ❖ 35 mm² 7/2.5 mm & 3000 m \pm 2% per drum.

5-3 A. C. S. R conductor

For this conductor, the applicable paragraphs of article 4 are: 4.3 & 4.4

The sizes of conductor required are as follows:

- ❖ 210/35 AL 26/3.20 mm St 7/2.49 mm & 2000 m \pm 2% per drum.
- ❖ 120/20 AL 26/2.44 mm St 7/1.90 mm & 2000 m \pm 2% per drum.
- ❖ 95/15 AL 26/2.15 mm St 7/1.67 mm & 2000 m \pm 2% per drum.

6. TECHNICAL INFORMATION:

The tenderer is requested to give the following information with his offer:

- 6-1 Nominal sectional area in sq. mm.
- 6-2 Stranding details i.e. number of strands and strand diameter.
- 6-3 Sectional and overall diameter.
- 6-4 Weight of conductor in Kg. Per Km – in case of ACSR the weight of steel is also to be given.
- 6-5 Percentage conductivity at 20 C°.
- 6-6 Percentage elongation.
- 6-7 Minimum breaking strength.
- 6-8 Maximum resistance at 20 C°.
- 6-9 Maximum permanent current carrying capacity under Iraqi climatic conditions (A).
- 6-10 (1) sec. Short – circuit current carrying capacity (KA).

7. TESTS:

- 7-1 All tests are to be carried out according to the relevant specifications.
- 7-2 The tests shall be carried out in the presence of an authorized body appointed and paid by you to verify the compliance with the specifications. The contractor shall at his own expense, provide all necessary-testing facilities at his work for carrying out the requested tests.
- 7-3 The test reports shall contain clear and detailed references to the relevant IEC recommendations and national standards, comparing the requested values and the actual ones.

NOTE

- ❖ The prices for Aluminum should be based on L. M. E USD 1600/MT.
- ❖ Variation formula should be stated clearly to indicate the price.
- ❖ Variation related to Km of manufactured conductors.

COMMISSION of ELECTRICITY
Planning and Studies division
Baghdad – IRAQ

Specification NO.	D-4
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Technical Specification
OF
L.V POWER CABLE

REVISION	Year 2001		
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1- SCOPE OF TENDER:

This tender includes for the manufacturing, testing packing shipping delivery ex-works, FOB & C&F of (6.0/1K) (1.2/2kV).

2- GENERAL REQUIREMENTS:

The material shall be of first class quality and designed for continuous satisfactory operation as continuity of supply is of prime importance and to operate satisfactorily under variation of load, voltage and short circuit of other conditions which may occur on the system provided that these variations are within the designed rating of the apparatus.

The material used shall be suitable for the following climate and soil condition.

2-1 Ambient temperature

Highest maximum (in the shade) 55 C for about six hours a day.

Lowest minimum (-10) C.

Maximum yearly average (+30) C.

Maximum daily average (+40) C.

2-2 Sun temperature

Black objects under sunshine attain a temperature of 80C.

2-3 Air humidity

maximum 92% at 40 C

minimum 12%

yearly average 44%

2-4 Altitudes

From sea level up to (1000 m)

3-TECHNICAL REQUIREMENT:

3-1 System Data

a. Nominal voltage	400 Volts
System	3phases, 4 wires with neutral solidly grounded.
Frequency	50 HZ

3-2 Standards

the cable shall be in accordance with the latest issue of the I.E.C (particularly NOS502 & 228).

3-3 Deviations

the tender shall particularly mention in his tender all deviations of his offer from the specification described in these tender documents.

4-GENERAL CABLES CHARACTERISTICS:

4-1 Conductor

Non-compact electrolytic annealed stranded plain circular copper conductor of high conductivity 99-9% purity.

4-2 Insulation

Extruded PVC (polyvinyl chloride) according to I.E.C table.

4-3 Core colours

Coloured for phase identifications (Red, Yellow, blue for phase) and black neutral.

4-4 Filler and Bedding

The four core then laid up with suitable fillers to form a compact circular assembly and bedded with a layer of extruded P.V.C.

4-5 Metallic Armour (for multi-core cables)

The four cores then armoured with double galvanized steel tapes of thickness according to I.E.C clause 12.4.

Each tape layer shall be applied in open helix with the second tape covering the gap left by the first, the gap shall be more than 25% of tape width.

4-6 PVC jacket (st2 table 4 in IEC 502)

Over all extruded PVC sheath water proof grey colour of thickness according to IEC and across section marking of (400 Volts) in the Arabic language should be stamped each one meter cable length and chemically antitermite and pollution. Also name, year of manufacturing, voltage and cross-section in the Arabic language.

4-7 Packing

The required cable length are to be supplied on sea.

Worthy good quality drums of length as specified NO.5 below.

5-TYPES OF CABLES

5-1 Single core cable

50mm²

5-1-2 70 mm²

5-1-3 95mm²

5-1-4 150mm²

5-1-5 240 mm²

For these cables the applicable paragraph are 4.1,4.2 and 4.6 on 250m length drums.

5-2 Four core cables

5-2-1 3x240+120mm²

5-2-2 3x150+70mm²

5-2-3 3x95+50mm²

5-2-4 3x70+35mm²

5-2-5 4x50mm²

5-2-6 4x25mm²

5-2-7 4x50mm²

For these cables, the applicable paragraphs are 4.1,4.2,4.3,4.4,4.5, and 4.6 for the cables from 240mm² to 95mm² on 250m good quality drums for cables from 50mm² to 16mm² on 1000m drums.

6- TECHNICAL INFORMATION:

The tendered is requested to give the following information with the offer:

6-1 Resistance of copper per km of cable.

6-2 Inductance of copper per km of cable.

6-3 Capacitance of copper per km of cable.

6-4 Insulation resistance in M. ohms between core/screen.

6-5 Weight of copper per km of cable.

6-6 Overall weight per km of cable

6-7 Overall diameter of cable

6-8 Type of technical treatment against termite in outer sheath.

7-TESTS

Cable shall be subjected to inspection and tests by our inspectors or international inspectors at any time during manufacturing. The manufacturers shall provide inspectors facilities for any said inspection shall be made at place of manufacturer or at international testing facilities.

**Ministry of Electricity
Power Distribution Office
Baghdad - Iraq**

Specification No.	D 46-
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**TECHNICAL SPECIFICATION
OF
LATTICE STEEL POLES**

REVISION	YEAR 2001	YEAR 2009	YEAR 2012
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1- Scope of supply: -

Suppliers are called upon to deliver lattice steel poles and cross-arm to MOE which required for the installation of medium voltage (11 kV), and low voltage (0.4 kV) Electricity Distribution Network usually our network using tubular steel poles but the lattice pole shall be used in - between for the following purposes: -

- a- Tensioning of the Network.
- b- At corners of Network.
- c- At end of Network.

The Japanese Industrial Standards (JIS) are to be considered in the design, manufacture and testing of the above mentioned materials. Similar or equivalent international standards such as BS or DIN shall be treated likewise. Specifications and quantities are stated in the following items.

2- General Requirements:

The materials shall be of first class quality and designed for continuous satisfactory operation as continuity of supply is of prime importance and to operate satisfactorily under variation of load, voltage and short circuit or other conditions which may occur on the system provided that these variations are within the assigned rating of the apparatus. The materials used shall be suitable for the following climatic conditions.

2 1-A ambient temperature:

Highest maximum (in the shade) 55 °C for about 6 hours a day

Lowest minimum (-10) °C

Maximum yearly average (+30) °C

Maximum daily average (+40) °C

2-2 Sun Shine temperature:

Black objects under direct sunshine attain a temperature of 80 °C

2-3 Air humidity:

Maximum	92% at 40 °C
Minimum	12%
Yearly average	44%

2-4 Altitudes:

From sea level up to (1000m)

2-5 Sand storm:

The equipments shall be suitable for outdoor installations and subjected to frequent sand storms and heavily polluted atmosphere.

2-6 Wind Velocity:

Max velocity (for design purpose) (140 KM/ HR) or 39m/sec.

2-7 Composition of Soil:

The soil consists mainly of hard clay containing deposit gravel.

3- Technical Requirement:

3-1 System Data

a.11 KV System	
Nominal voltage	11000 volts
Highest system voltage	12000 volts
System	3-phase, 3wire neutral earthed through resistance of 21.1 Ohm limiting the earth fault current to 300A
Short circuit breaking current	25 KA R.M.S at 11000 volts

b. 0.4 kV system	
Nominal voltage	400 Volts
System	3phases, 4 wires with neutral solidly grounded.
Frequency	50 Hz

4- Materials and process: -

The poles shall be made from hot rolled I- joists and angle-steel sections with steel plates specified in JIS-G-3101 (STK-51) or in accordance with BS 4360 (Steel 52) or in DIN 17100 or in accordance with any international equivalent standard with considering the design factor of safety equals to (2.0) having the following properties:

Characteristics	Unit	Steel type		
		STK-51	Steel 52 (to BS 4360)	Steel 52 (to DIN 17100)
Tensile strength	Kg f/mm^2 (min)	51	52	52
Yield strength	Kg f/mm^2	36	36	34.5
Design bending stress	Kg f/mm^2 (min)	25.5	26	26

Materials for A-clamps used at the top of (11 m lattice steel poles) and cross-arms shall be made of hot rolled structural carbon steel in accordance with the same specifications above but either STK-51, Steel-52 (to BS or DIN) having the following mechanical properties: -

5- Lattice-steel poles:

Each low voltage lattice steel pole shall be made out of two Nos. I-steel joists which are to be welded together and cross-braced with angle iron size (30×30×3) of steel (ST-41) or (ST-37) or any equiv. forming the shape of latter (A) as shown in drawings No. (2). I-steel sizes for low voltage is as follows: -

(120×58×5.1×7.7) ST-52 according to DIN-17100.

(125×75×5.5×9.5) STK-51 according to JIS-G-3101.

Any equivalent sections ST-52 according BS-4360.

And for medium voltage lattice steel pole is as follows: -

(140×66×5.7×8.6) ST-52 according to DIN-17100.

(150×75×5.5×9.5) STK-51 according to JIS-G-3101.

Any equivalent sections ST-51, ST-52 according BS-4360.

And any other size having the same modulus of section shall be acceptable.

a- Low-Voltage Lattice Poles:

The lattice pole which is shown in drawing No. (1) shall serve as a tension, angle and end-pole for low voltage network using straight-line tubular poles. The lattice pole should be capable of withstanding a working load of (700 Kgf) acting vertical to its plan in the transverse and longitudinal directions at the poles top. Planting depth shall be (1.5 m) for (9 m) poles. The rest of dimensions and parameters as per drawing No. (2) attached and also for locations of holes. Inspection shall takes into consideration (JIS-G-3101, G-3191 & G-3192) . The whole pole shall be hot-dip galvanized according to BS 729.

b- Medium Voltage Lattice Poles: -

This pole shall be used as a tension, angle (0-65°) and end-pole for (11 kV) power transmission lines together with straight line tubular poles. Referring to drawing No. (1) this pole has to withstand the max. working loads (700) Kgf. Planting depth shall be (2m) for (11 m) poles. The rest of dimension, parameters, locations of hole shall be as per drawing no. (1) attached. (A-clamp) as per drawing no. (2) shall be welded to the top of each pole. Inspection shall takes into consideration (JIS-G-3101, G-3191 & G-3192). The whole pole shall be hot-dip galvanized according to BS 729.

c- Common Remarks For Lattice Poles: -

- c-1 Each of the (9&11 m) lattice steel poles shall have an earthing hole (18 mm dia.) located at the center of the lower plate for earthing purposes.
- c-2 Every steel lattice pole shall be supplied with (11 Nos.) electrically galvanized, high stress, hexagonal -headed (M-16) fully threaded bolt (35 mm) length of screw with nut, plain washer & spring washer as they are used as follows.
- (10 Nos.) For the 2 rows of (5x18 mm) dia. holes of each pole. (1 No.) For the (18 mm) dia. earthing these bolts, nuts...etc shall be firmly tightened in their places on the poles at the manufacturing works to guarantee supplying each pole to our job-site complete. (5%) spare bolts, nuts...etc shall be supplied as a spare individually.

6- Testing

All materials under contract shall be tested at the manufacturing works to verify compliance to our specifications. The MOE shall appoint an inspector for this purpose and paid accordingly, but the manufacturer shall supply all equipment and facilities to our inspector necessary for conducting all such tests without extra charge, the tests shall include the followings: -

- a- Mills certificate approved by the manufacturer for the materials like I-joist, angle-steel, steel plates, channel steel, bolts & nuts...etc.
Complying fully with the international specifications based upon.
- b- Dimensional tests in quantities not less than (5%) of the quantity of each batch, taking into consideration that eccentricity between top and bottom part of the pole shall not exceed 1/1000.
- c- Welding tests by x-ray at the rate of two tests per each 100 Nos. of lattice poles.

d- Loading Tests (type test):

The design of each pole shall have the acceptance arteries as follows when conducting loading tests.

Load	Measuring item	Acceptance criteria
Ps	Specified working load	Any defect should not be produced
O	-----	-----
Pp	Ps × 1.5 load	Any defect should not be produced
O	-----	Permanent set shall not exceed (13 mm) from zero position
Pb	Ps × 2.0 load	Destruction

Where: -

Ps = Specified working load.

Pp = Load for permanent set not exceeding (13 mm).

Pb = Breaking load.

The loading test shall be carried out at rate of one test per each batch of 500 Nos. of lattice poles manufactured. The distracted pole shall not be considered from our poles. The manufacturer to replace the tested sample shall supply another.

e- Galvanizing:

Test shall be carried out on samples of the materials under contract as per BS 729.

7- Packing:

The manufacturer shall states clearly in his offer the proposed packing of the materials under contract mainly for the lattice poles and how many poles in each bundle. The cross arms and accessories shall be supplied in suitable bundles as well.

8- Alternative design:

The tendered may offer an alternative design for the lattice poles, but the new design shall take the following points into consideration.

- a- Same applied working load.
- b- Same total lengths of pole.
- c- Same locations of the medium voltage and low voltage conductor.
- d- Suitability of the cross-arms to the (11 m) lattice poles.

9- Specification For The Cross-Arms

The cross-arm shall be used to support insulators carrying bare copper or aluminum conductors on the medium voltage poles (11 m) they are to be made of section (channel steel) (ST-41), (ST-42) , (ST-44) or any equiv. Flat steel, bolts, nuts and washers according to (JIS-G-3101 and JIS-G-1186) or equivalent and as per drawing (No. 3) attached. All steel work shall be hot dip galvanized to BS 729 but bolts nuts; washers shall be electrically galvanized.

- 10. **Options:** as an option the poles could be painted type with two anti-oxide (red laite) paint layers with cross arms. According to the tender's request bolts and nuts to be electrically galvanized.

Note:

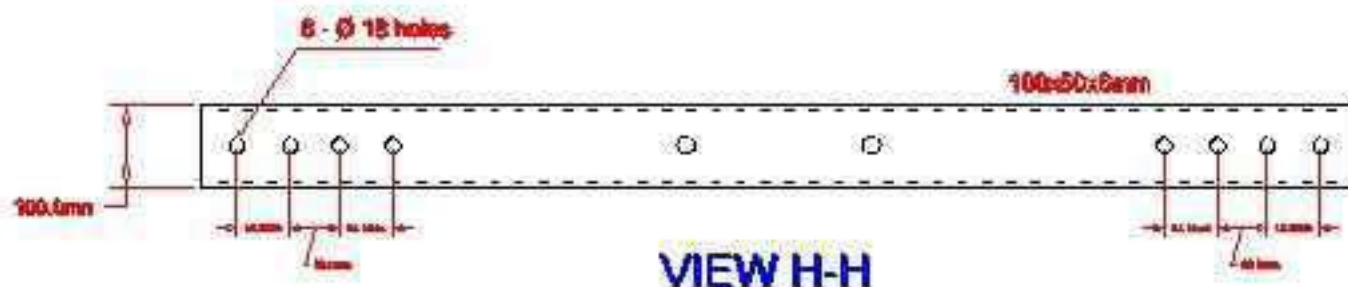
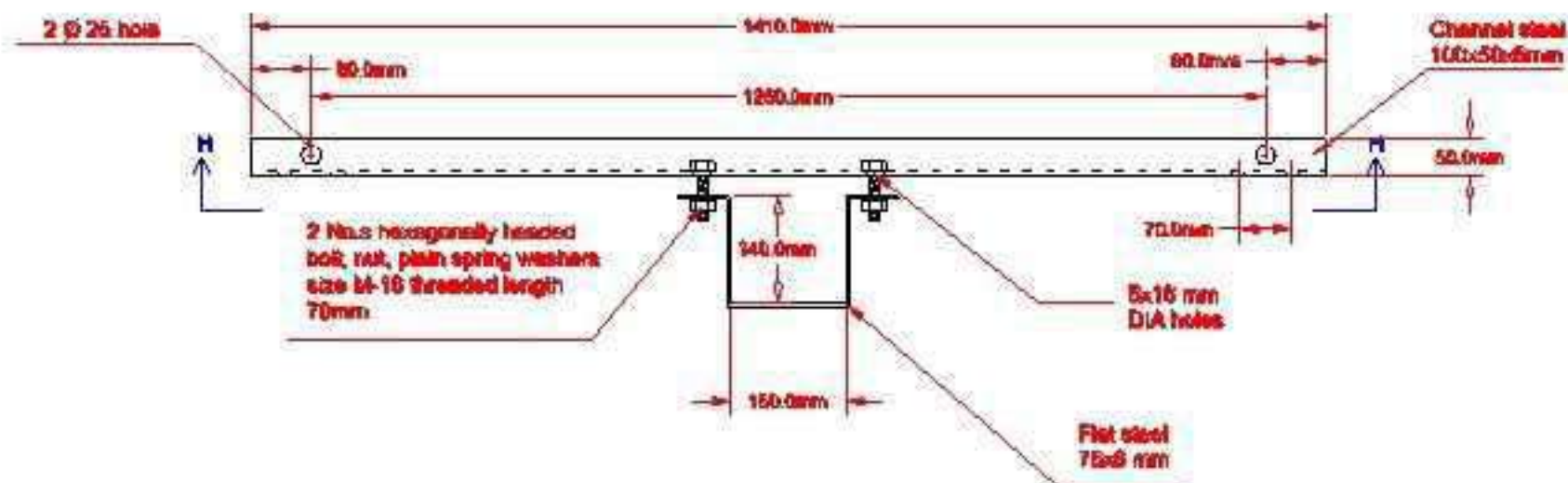
All drawings of the pole and its accessories subjected to our approval before start manufacturing.

[illegible]

9m Lattice poles

All steel, Hot dip galvanized to BS 728

Drawing no. (1)



All materials STK-41 or ST-42 Hot dip galvanization to B.S729 for all steel works except bolts which should be electrically galvanized

Drawing no. (2)

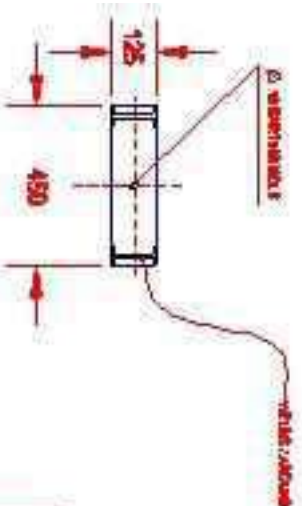
CROSS ARM FOR 11m LATTICE POLES



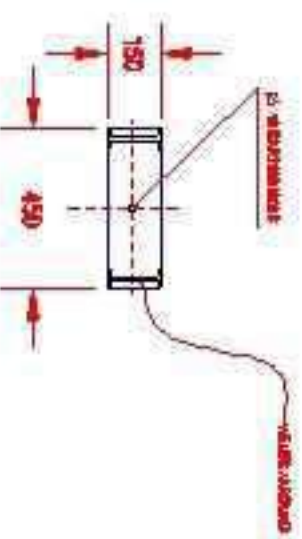
Drawing no (3)



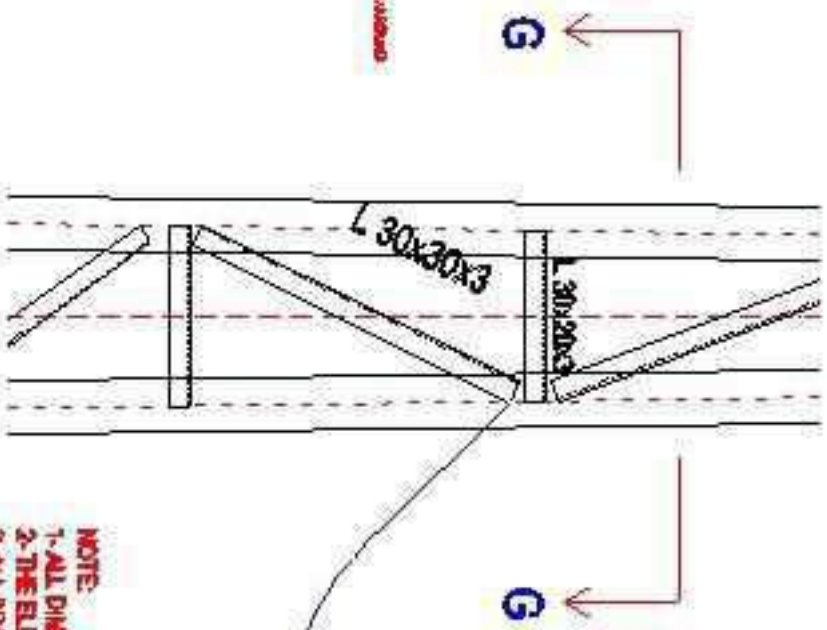
VIEW G-G



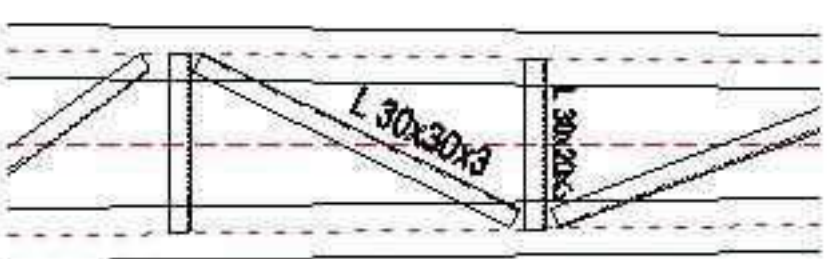
SECTION E-E



SECTION A-A



FRONT ELEVATION



BACK ELEVATION

- NOTE:**
- 1- ALL DIMENSIONS ARE IN MILLIMETERS
 - 2- THE ELEVATION OF TWO HOLES CAN BE CHANGED
 - 3- ALL BRACING & WELDING OF L 30x30x3 (51-57) SHALL BE DOWN INSIDE THE LISTS
 - 4- IF NO.5 BOLTS, NUTS, WASHERS, ETC. SHALL BE FIXED ON EACH POLE BEFORE SHIPMENT WHICH ARE USED FOR FIXATION OF D ROP SHACKLE INSULATORS EARTING.

**Ministry of Electricity
Power Distribution Office
Baghdad - Iraq**

Specification No.

D 22-

**TECHNICAL SPECIFICATION
OF
TUBULAR STEEL POLES**

REVISION

YEAR 2001

YEAR 2009

YEAR 2012

1- Scope of supply:

Suppliers are called upon to deliver tubular steel poles to MOE which are required for the installation of medium voltage (11 kV) and low voltage (0.4kv) Electricity Distribution Network.

The Japanese Industrial Standards (JIS) or British Standards (BS) are to be considered in the design, manufacture and testing have above mentioned materials. Similar or equivalent international standards such as A.P.I or DIN etc. Shall be likewise.

2- General Requirements:

The materials shall be of first class quality and designed for continuous satisfactory operation as continuity of supply is of prime importance and to operate satisfactorily under variation of load, voltage and short circuit or other conditions which may occur on the system provided that these variations are within the assigned rating of the apparatus. The materials used shall be suitable for the following climatic conditions.

2 1-A mbient temperature:

Highest maximum (in the shade) 55 °C for about 6 hours a day

Lowest minimum (-10) °C

Maximum yearly average (+30) °C

Maximum daily average (+40) °C

2-2 Sun Shine temperature:

Black objects under direct sunshine attain a temperature of 80 °C

2-3 Air humidity:

Maximum	92% at 40 °C
Minimum	12%
Yearly average	44%

2-4 Altitudes:

From sea level up to (1000m)

2-5 Sand storm:

The equipments shall be suitable for outdoor installations and subjected to frequent sand storms and heavily polluted atmosphere.

2-6 Wind Velocity:

Max velocity (for design purpose) (140 KM/ HR) or 39m/sec.

2-7 Composition of Soil:

The soil consists mainly of hard clay containing deposit gravel.

3- Technical Requirement:

3-1 System Data

a.11 KV System	
Nominal voltage	11000 volts
Highest system voltage	12000 volts
System	3-phase, 3wire neutral earthed through resistance of 21.1 Ohm limiting the earth fault current to 300A
Short circuit breaking current	25 KA R.M.S at 11000 volts

b. 0.4 kV system	
Nominal voltage	400 Volts
System	3phases, 4 wires with neutral solidly grounded.
Frequency	50 Hz

4- materials and process:

The poles shall be made from longitudinally welded tube sections of hot rolled structural carbon steel in accordance with JIS-G-3444 or in accordance with BS-4360 or in accordance with any international equivalent standards like DIN 17100 with considering the design factor of safety for design of the poles shall be considered (2.0). Then the materials having the following properties.

Characteristics	Unit	type of steel standards			
		High tensile steel		Medium tensile steel	
		according to JIS-G-3444	according to BS-4360 DIN-17100	according to JIS-G-3444	according to BS-4360 DIN-17100
Tensile strength	Kg f/mm ² (min)	ST-51	ST-52	ST-41	ST-42
Yield strength	Kg f/mm ² (min)	36	36	24	24
Design bending stress	Kg f/mm ² (min)	25.5	26	20.5	21

Poles shall be delivered in a swaged or stepped form.

Swaged poles shall be manufactured from tubes brought together when hot. Stepped poles shall be made from one length of tube with its diameter being reduced in parallel steps by passing the tube through a series of dies. Stepped poles shall have the same wall thickness at any section of its whole length.

A swaged pole shall consist of three-tube section with diminishing diameters, the bottom Section being the biggest in size. See fig (1).

The length of the overlap shall be at least 3 times . The diameter of the smaller tube. The supplier should state the overlapping length in his offer. The upper edge of tube at the joint shall be chamfered off at an angle of 45°

The top end of all poles shall be rounded off and sealed completely. Welded type poles made out of three- sections similar to the design but jointed together via reducers welded to the pole section shall also be accepted subject that the mechanical characteristics and tests are the same as for swaged or stepped poles.

a. The pole design shall be in accordance with the following: -

Characteristics	Unit	9m poles (LV)	11m poles (MV)
Effective length of pole	m	9	11
Length of top section	m	2	2.5
Outside diameter of top section	mm	89	114
Length of middle section	m	2.3	3
Outside diameter of middle section	mm	114	139
Length of bottom section	m	4.7	5.5
Outside diameter of bottom section	mm	139	165
Planting depth	m	1.5	2
Working load	kgf	210	285
Point of application of load		60 cm below top	120 below top
Allowable bending stress For JIS-G-3444 ST-51 & DIN-17100 ST-52	kgf/mm ²	26	26
Wall thickness (t) of the poles must be for ST-51 or ST-52	mm	≥ 3.7	≥ 4.4
Allowable bending stress For ST-41 JIS - G - 34444 & ST 42 according to DIN - 17100 and any equivalent	kgf/mm ²	21	21
Wall thickness (t) of the poles must be for ST-41 or ST-42	mm	≥ 4.4	≥ 5.3

b. All (11 m) pole shall be fitted with (A) shaped clamped welded to the poles top and having an approximate height of (25 cm). The clamp which shall be fixing the upper (11 kv) pin insulator, is to be made of plate steel having of chemical and mechanical properties similar to that of the tubular poles.

The plate shall have a width of (75mm) and (6mm) thickness with two holes (25 mm) diameter of steel (ST-41) or (ST-42), each drilled at center coincident with the centerline of the pole.

The extra length of ((A)) clamp shall not be considered in the effective length of the (11 m) pole.

c. Five nos. (17.5mm) dia. Through holes shall be drilled at the top sections of poles for the purpose of fixing low tension shackle insulators. The upper-most hole shall be located (120 cm) below the top of the (11 m) pole, the rest spaced (30 cm) between centers vertically downwards.

The same number of holes shall be drilled through the (9 m) poles, but the upper-most hole shall be drilled (15 cm) below the top.

For earthing purposes a (20-mm) dia. Hole shall be drilled at the bottom of each pole at a distance of (15-cm) there from and a suitable length (M-18) galvanized bolt, nut & washer shall be supplied with each pole.

Tolerance in diameter and thickness of tube section shall be within the limits specified in (JIS-G-3444, or BS 4360, or DIN 17100) the complete pole shall be out of straightness more than (1/1000) of length of pole.

d. Loading process (type test):

The design of each pole shall has the acceptance criteria as follows when conducting loading tests:

Load	Measuring item	Acceptance criteria
Ps	Specified working load	Any defect should not be produced
O	-----	-----
Pp	1.5 load × Ps	Any defect should not be produced
O	-----	Permanent set shall not exceed (13 mm) from zero position
Pb	2.0 load × Ps	Destruction

Where: -

Ps = Specified working load.

Pp = Load for permanent set not exceeding (13 mm).

b = Breaking load.

5- Protection: -

The poles shall be hot-dip galvanized thoroughly internally and externally as per (BS 729) but zinc distribution shall not be less than (650 gr. /m).²

6- Testing and inspection:

The poles are subject to inspection by (MOE) inspection authority during manufacture and before shipment to verify compliance of poles with our specifications. The fees shall be borne by (MOE) but the supplier shall submit all necessary facilities to our inspector to conduct such tests without-extra charge.

7- Specification For Cross-Arms & Clamps

Generally these cross-arms and clamps shall be used for (11 m) poles at the rate of one set of cross-arm and clamp per each pole shall be steel (St-41) or (St-42). The set shall be fastened at a distance of (0.9 m) below pole top (excluding A - clamp). Generally the design shall be complying fully with the attached drawings No.2 & No.3 . Every set shall include the followings: -

- One No. Channel steel (75x40x6 mm) length (1250 mm).
- One No. Clamp having cross-section (75x6 mm).
- Tow Nos. high stress ((M-16)) Hexagonal headed bolts, nuts, plain washer & spring washers, the length of bolt (excluding head shall be 60 mm, fully threaded 50 mm).With spare bolts, nuts. etc of 5% for the whole quantity required.

8. Protection:

- a. All channel steels and clamps shall be hot dip galvanized to (BS 729), with same zinc distribution as above.
- b. All bolts nuts and washers shall be electrically galvanized.

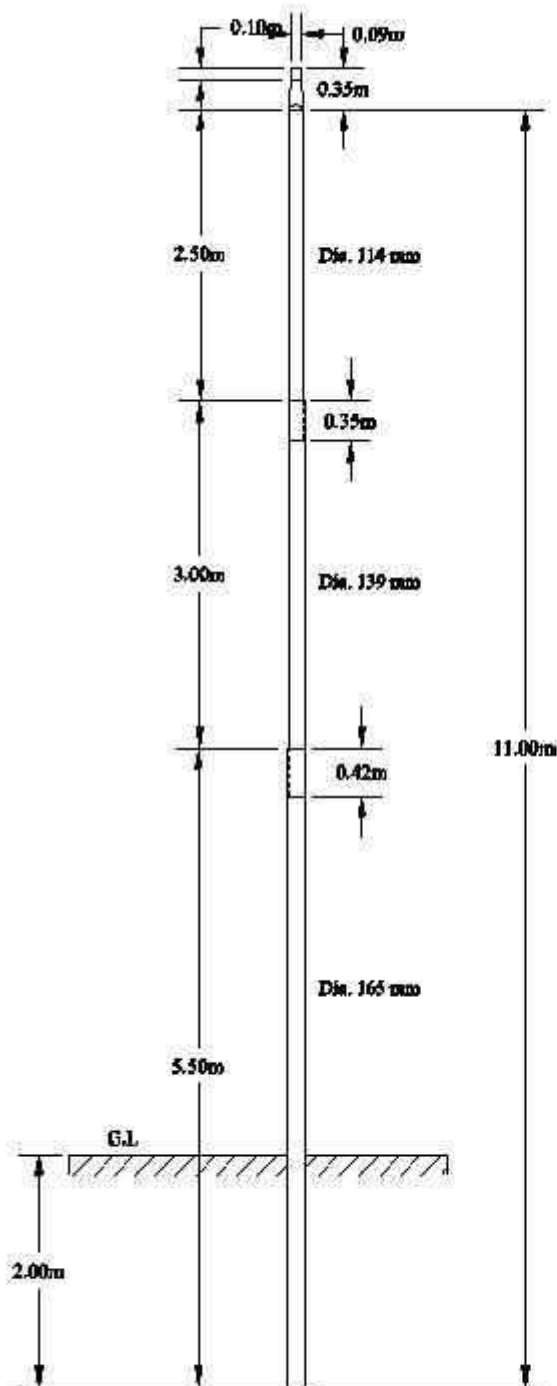
9. Packing:

- a. Channel steels and clamps in bundles.
 - b. Bolts nuts and washers in proper wooden or steel cases.
- Details shall be stated clearly in the offer.

Note:

All drawings of the pole and its accessories subjected to our approval before start manufacturing.

11m poles



9m poles

