Technical Specifications of

Finishing Works Project of two floors in Ministry of Interior Affairs Building
## SPECIFICATIONS AND LIST OF DRAWINGS
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SECTION A

GENERAL

A 1 SCOPE OF WORK

These Specifications cover all the works necessary for finishing works project of two floors in Ministry of Interior Affairs Building.

A 2 DRAWINGS

A list of Contract Drawing available at the date of tender is included on the front page of the Drawing Book and at the end of these Specifications.

A 3 CONTRACTOR'S PRICE

The Contractor's price shall include for all materials labour and plant requirements necessary for the completion of the Contract in accordance with the Contract Drawing and specifications with exception only of items supplied by the Employer.

A 4 USE AND PROTECTION OF SITE

The Contractor shall take such measures and exercise such are to protect the Site as shown on the Site Plan during the course of the Works as directed by and to the entire satisfaction of the Engineer.

All temporary buildings and work areas such as Site Offices, Workshops, Store Buildings and Yards, Living Accommodation, Messrooms, etc. shall be constructed in position approved by the Engineer.

The contractor shall confine his apparatus, the storage of materials and the operations of his workmen to limits indicated by law, ordinances, permits or directions of the Engineer. The Contractor shall erect suitable temporary fences as required by the Engineer.

The Contractor shall not load or permit any part of the structures to be loaded with a weight that will endanger its safety.

On commencement of the Contract, the Contractor shall clear the Site and adjacent area of all rubbish and debris to the satisfaction of the Engineer.
USE AND PROTECTION OF SITE (Cont'd)

Upon completion of the Contract, the Site and any adjacent areas affected by the building operation shall be properly cleared of all temporary works, debris and other rubbish and all disturbed works and ground made good to the entire satisfaction of the Engineer.

A 5 MATERIALS FOUND ON SITE

Any sand, gravel or other building material found on the Site shall not be used in the execution of the Works without the prior written consent of the Engineer, which shall not be unreasonably withheld.

A 6 TEMPORARY STORMWATER DRAINAGE

The Contractor shall ensure that the whole of the Site, is kept free from the risk of stormwater flooding and shall provide such temporary ditches, gullies and the like as may be necessary and shall at completion of the Works backfill such excavation and make good all works disturbed.

A 7 SHOP DRAWINGS

If at any time before the commencement or during the progress of the work it appears to the Contractor that for the proper execution of specific part of the works, shop drawings are necessary, these drawings shall be prepared by the Contractor and submitted to the Engineer for approval. On the other hand, the Engineer shall have authority to order at any time and the Contractor agrees to provide any number of shop drawings which in the opinion of the Engineer are necessary for the proper execution of a specified work, the Contractor shall not proceed with the above mentioned work unless these shop drawings are approved by the Engineer.

Shop drawings shall be fully detailed and drawn to proper scale.

Unless otherwise specifically required in the drawings or Specifications, shop drawings shall be supplied in four copies with dark lines on a white background.

Shop drawings shall be approved or returned to the Contractor for alteration or amendment within four (4) weeks of their receipt by the Engineer. Shop Drawings returned for alteration or amendment shall be resubmitted for approval. Altered or amended shop drawings shall show the nature of the alteration or amendment in a revision block on the drawings with a revision number or letter and the date of the revision.
A 8 "AS BUILT" DRAWINGS

All prints of the Drawings, where required, shall be corrected by the Contractor and submitted to the Engineer for approval as the works proceed. Upon the completion of the Works, the Contractor shall prepare a completely new set of drawings for the project as executed and submit same in duplicate to the Engineer for approval.

When approved by the Engineer, the Contractor shall submit one transparency and six copies of all drawings duly marked "As-Built". The final payment shall not be made except for the actual works that have been completed in accordance with the Specifications and have been duly presented on the "As-Built Drawings".

The Contractor shall not be entitled to any extra payment or extension of time for the correction, preparation and supplying of the above mentioned drawings and transparencies.

A 9 SCAFFOLDING

The Contractor shall provide, erect, maintain, and dismantle any clear away at completion proper and adequate scaffolding including that required for Sub-Contractors and Specialists. Putlong holes shall be made good to match the adjacent surface as the scaffolding is dismantle. The Contractor shall be entirely responsible for all safety precautions in connection with the scaffolding and for its entire sufficiency for the work.

A 10 PROTECTION

In the pursuance of his obligations under the Conditions of Contract, the Contractor shall wherever required or directed by the Engineer cover up and protect the Works form the weather and from damage by him or other workmen performing subsequent operations. He shall provide all necessary dustsheets, barriers and guard rails and clear away same at completion.

The Contractor shall take all reasonable and proper steps for the protection of all places on or about the Works, which may be dangerous to his workmen or any other persons or to traffic. The Contractor shall provide and maintain warning signs, red warning lamps and barricades as necessary in all such places.
A 11 SEPARATE CONTRACTS

The Employer reserves the right to let other separate contracts in connection with the work under similar conditions. The Contractor shall afford other contractors reasonable opportunity for the introduction and storage of their materials and the execution of their work, and shall properly connect and co-ordinate his work with theirs.

If any part of the Contractor's work depends for proper execution or results upon the work of any other contractor, the Contractor shall inspect and promptly report to the Engineer and defects in such work shall render it unsuitable for such proper execution and results.

His failure so to inspect and report shall constitute an acceptance of the other Contractor's Works as fit and proper for the reception of this work, except as to defects which may develop in the other Contractor's work after the execution of his work.

To ensure the proper execution of his subsequent work, the Contractor shall measure work already in place and shall at once report to the Engineer any discrepancy between executed work and the Drawings.

A 12 DEFINITIONS

"Approved "directed "selected" means the approval, direction or selection by the Engineer.

"Instructions means the instructions in writing of the Engineer or Engineer's Representative unless specified otherwise.

"Manufacturer's Recommendation" means the Manufacturer's recommendations or instructions, printed or in writing and current at the date of tender.

"Or approved equal" means that materials of different manufacturer may be substituted if proper approval has been obtained. The rates or prices will be held to be based on the materials specified.

Where an item is denoted as N.I.C. on the Drawings it shall mean that item indicated is not included in the Contract.

Where the terms Architect or Engineer is used in this Contract they shall have the same meaning.

Where the terms Architect's Representative or Engineer's Representative are used they shall have the same meaning.
A 13 STANDARDS

In the Contract reference is made to the Standards, Codes of practice and Specifications issued by the following organizations, hereinafter referred to by the following abbreviations:

AASHO Means the American Association of State Highway Officials.

ACI Means the American Concrete Institute.

AFNOR Means the Association Francaise de Normalisation.

AISC Means the American Institute of Steel Structure.

ASA Means the American Standards Association.

ASHRAE Means the American Society of Heating, Refrigerating and Air-Conditioning Engineers

ASTM Means the American Society for Testing and materials.

AWWA Means the American Water Works Association.

BS Means the British Standards Institution.

CMA Means the Cable Manufacturers Association.

DIN Means the Deutscher Normauusschuss.

NEMA Means the National Electrical Manufactures Association.

NFPA Means the National Fire Protection Association.

VDE Means the Verban Deutscher Electrotechniker

These references shall in every case be deemed to include the latest edition or issue of such standards.

The Contractor upon receiving instructions shall supply the Engineer’s Representative with single copies of all standards referred to on the Drawings or Specification and shall arrange for further copies for his own use.
A 14 MATERIALS GENERALLY

All materials and manufactured goods are to be the best of their respective kinds and as described in the Specifications and the Contractor shall submit for the approval of the Engineer a list of names and addresses of the manufacturers, the trade marks and types of all materials and articles he proposes to employ together with all specifications and descriptions that may be required in this connection before any orders are placed. Samples are to be provided if requested by the Engineer. Where a particular proprietary product, supplier's catalogue is referred to in the Specifications or shown on the drawings the material specified may be obtained from another source provided it is similar, equal and approved by the Engineer.

If during the course of the Contract certain materials required for use in the Works should be unobtainable despite the best efforts of the Contractor, then the Contractor may offer for the approval of the Engineer substitute materials.

The use of these substitute materials shall be at the sole discretion of the Engineer.

In the event of the acceptance of the substitute materials a suitable price reduction shall be made in the respect of decrease in quality or value but no price addition shall be made in respect of increase in quality or value.

In the event of refusal of the substitute materials the Contractor shall not be relieved of any of his obligations under the Contract and shall be solely liable for any delay or loss occasioned by his failure to provide materials as specified.

Where manufacturers recommendations have been entered into the contract documents, it is for the purpose of giving an indications to the contractor of the Engineer’s intentions on the application and use of the material.

It is deemed that the successful Contractor will make direct contact with the manufacturer m to ensure that he is carrying out the works in accordance with their recommendations.

A 15 CONTRACTOR TO VERIFY SITE MEASUREMENTS

The Contractor shall check and verify all site measurements wherever requested by other specialist contractors or by nominated or other sub-contractors to enable the to prepare their own shop drawings, and pass on the information with sufficient promptness as will not in any way delay the Works. A copy of all such information passed or shall be given to the Engineer.
A 16 SAMPLES

The Contractor shall furnish for approval, with reasonable promptness all samples of materials and workmanship required by the Engineer. The Engineer shall check and approve such samples with reasonable promptness for conformance with the design concept of the works and for compliance with the information given in the Contract Documents. The Work shall be in accordance with approved samples.

a) All material samples shall be delivered to the Engineer’s office with all charges in connection with therewith paid by the Contractor.

b) Duplicate final approval samples, in addition to any required for the Contractor’s use, shall be furnished to the Engineer.

c) Samples shall be furnished so as to delay fabrication allowing the Engineer reasonable time for consideration of the sample submitted.

d) Each sample shall be properly labelled with the name and quality of the material, manufacturer’s name, name of project, the Contractor’s name and the date of submission and the Specification number to which the sample refers.

A 17 CUTTING AND PATCHING

The Contractor shall be responsible for all cutting, patching and making good in all trades for all work and his prices will be deemed to include for all such cutting and patching and making good.

A 18 SITE OFFICES, LATRINES, ETC.

The Contractor shall provide and maintain on the Site for the duration of the Contract the following: -

a) A temporary office for the accommodation of his Agent/Engineer and Staff, including all necessary sanitary facilities, such offices shall be open at all reasonable hours to receive instructions, notices or other communications. Telephone and Electric installations shall also be provided.

b) A suitable and adequate temporary office shall be provided and furnished by the Contractor for the sole use of the Engineer and his staff. Such office shall be to the approval of the Engineer.

c) Adequate fire fighting equipment to the approval of the Local Fire Authority and the Engineer.

d) An approved sign board, written in Arabic and English. The size of signboard and lettering including to wordings shall be as directed by the Engineer.
A 19 ATTENDANCE ON THE ENGINEER

The Contractor shall for the duration of the Contract supply sufficient attendance for the Engineer’s supervisory staff and shall maintain and pay all water, electricity, and telephone charges shall keep the Site Office and supervision cabins in a clean and sound condition at all times.

The Contractor shall be responsible for the security of the Site Office and its contents at all times and shall employ watchman for this purpose.

A 20 TESTING

The Contractor shall allow in his rates and prices for the cost of carrying our tests necessary for compliance with the Specification in independent laboratories outside the Site.

A 21 TEMPORARY BUILDINGS

The Contractor shall provide and maintain on the Site sheds, offices, messrooms, sanitary accommodation and other temporary works of any kind whatsoever for the Contractor’s supervisory staff and work people and for Sub-Contractor’s staff employed upon the works.

The Contractor’s site office shall be open during working hours to receive instructions notices or other communications.

Sheds shall be suitable to store all materials equipment and furniture which in the opinion of the Engineer needs protecting from the weather.

The Contractor shall provide and maintain in approved positions on the Site Adequate sanitary accommodation for his staff workmen and sub-Contractors. This sanitary accommodation shall be kept in a clean and orderly condition to the approval of the Public Health Authority and the Engineer to ensure that no nuisance is caused.
The Contractor shall provide and maintain all temporary roads and tracks necessary for movement of plant and materials, and clear same away at completion and make good all works damaged or disturbed.

The Contractor shall submit drawings and full particulars of all Temporary Works to the Engineer before commencing same. The Engineer may required modifications to be made if he considers them to be insufficient and the Contractor shall give effect to such modifications but shall not be relieved of his responsibilities for the sufficiency thereof.

The Contractor shall divert as required, at his coast and to the approval of the Engineer, all public utilities encountered during the progress of the Works, except those specially indicated on the drawings as being included in the Contract.

Where diversions of services are not required in connection with the permanent Works, the Contractor shall uphold, maintain and keep the same in working order in existing locations.

The Contractor shall make good, at his own expense, all damage to telephone, telegraph and electric cable or wires, sewers, water, or other pipes except where the Public Authority or Private Party Owing or responsible for the same elects to make good the damage. The cost incurred in so doing shall be paid by the Contractor to the Public Authority or Private Party in demand.

All injury to the surface of the land, to the beds if water courses, projecting banks, etc. where disturbed by the Works (other than where specifically ordered by the Engineer) shall be repaired by the Contractor or the authorities concerned, at the Contractor’s expense. All such making good shall be to the approval of the Engineer.

All requirements detailed above shall be provided and maintained at the expense of the Contractor.

The Employer shall not be liable for loss or injury to and Temporary Works.

The Contractor shall make all necessary arrangements and provide all water for the proper execution of the Works, together with all transport temporary plumbing, storage and distribution, pay all charges and alter adapt and maintain temporary work as necessary remove and make good at completion.
A 24 ELECTRICITY FOR THE WORKS

The Contractor shall make all necessary arrangements and provide all artificial lighting and power for the proper execution and security if the Works and its protection.

With all meters temporary wiring and fittings, pay all charges and alter, adapt and maintain the temporary works as necessary and remove and make good at completion.

A 25 PROVISION OF PLANT AND TOOLS

The Contractor shall provide and install all necessary hoists, ladders, scaffolding. Staging, tackles, tarpaulins, tools, vehicles, and other plant (mechanical and otherwise) and allow for altering adapting and maintaining them in good condition as necessary and eventually removing from site and making good.

A 26 TEMPORARY BARRIERS, FENCING ETC...

The Contractor is to provide all temporary barriers, fencing, hoarding, guard rails, gates, and the like as may be necessary to protect the public and others, for proper execution of the Works and shall remove and clear away at completion of the Works and make good all work disturbed.

A 27 INCONSISTENCY IN CONTRACT DOCUMENTS

The Contractor shall execute the Works according to the provisions of the Contract Documents. Any work indicated in one of the documents but omitted and/or stated in one or more of the other documents shall be treated as though it were included in all of them.

If any two documents of the Contract conflict as to the quality of the work to be carried out, the discrepancy shall be brought to the notice of the Engineer, who shall instruct the Contractor which of the two conflicting documents to regard as correct.

If the Contractor should discover that any work has been omitted and/or not indicated entirely or partially from all the documents, but that such work is essential to the safety or proper functioning of the works, he shall report the facts immediately to the Engineer. If the work is something which in the opinion of the Engineer could not have been foreseen by an experienced Contractor, the Engineer should issue to the Contractor a variation order stipulating the details of the work to be done.

Save as aforesaid in the above paragraph, no additional payment shall be made in respect of work carried out in connection with discrepancies between the various Contract Documents.
A 28 ERRORS IN COMPUTING CONTRACT DOCUMENTS

The Contractor shall be responsible for any error which he makes in computing any quantities of material and labour required or costs involved or through any lack of knowledge of the Site or misunderstanding of anything shown or implied on the Drawings or in the Specifications and/or the Bills of Quantities.

The Contractor must refer any discrepancy in the Drawings or the Specifications to the Engineer before proceeding in any of the Works otherwise the decision of the Engineer as to the interpretation of the discrepancy will be final. Any item or items of work not specifically shown on the Drawings or referred to in the Specifications but which would be necessary for the proper construction of the works in accordance with the best practice is implied and must be included for as incidental to the Contract Sum. Any item for which the Contractor has not inserted a price in the Bills of Quantities shall be deemed to be covered by other prices or rates therein.

A 29 SITE MEETINGS

During the course of the Works, site progress meetings shall be held at regular intervals at least once every two weeks in the presence of the Engineer for the purpose of co-ordinating the Contractor’s work and to insure that full compliance with the various sequences of the contract are maintained. Minutes of such Site meetings will be recorded, copies will be distributed to all persons concerned and full effect shall be given to all instructions contained therein.

Prior to such meetings the Contractor shall give to the Engineer’s representative details in writing of that portion of the Works he proposes to construct during the coming two weeks with details of the plant and methods he proposes to employ. These proposals shall be discussed at the meeting and no work based on such proposals shall proceed without the approval of the Engineer’s Representative.

The Contractor shall have no claim against the Employer for costs incurred by him in changing the method of working or in the provision and use of other additional plant.

A 30 DAILY REPORTS

The Contractor shall deliver daily to the Engineer’s Representative a report as to the number of workpeople employed on the Works in each Trade and copies of delivery notes of all materials and goods to the Site during the day.
A 31 ACCESS FOR THE ENGINEER

The Contractor shall provide at all times during the execution of the Works and the Maintenance Period proper means of access with ladders, gangways etc., and the necessary attendance to move and adapt same as directed for the inspection or measurement of the Works by the Engineer or the Engineer’s Representative.

A 32 SETTING OUT AND LEVELLING

Prior to commencement of any site work the Contractor shall arrange to record on an approved grid existing site ground levels and agree with the Engineer’s Representative the accuracy thereof by preparing a record drawing signed by the Contractor’s Agent and the Engineer’s Representative. The Contractor shall set out and level the Works and obtain the approval of the Engineer’s Representative before commencing construction.

A 33 PROGRAMME TO BE FURNISHED

The Contractor shall prepare a programme for the Works, including the work of subcontractors and other work concurrent with the Contract, using the critical path network method. The Contractor shall submit three (3) copies of programme to the Engineer with his tender. Submission of programme will not relieve the Contractor of his obligations to apply in writing for instructions as required by the Conditions of Contract. Receipt of programmes by the Engineer shall neither affect the Contract completion date nor relieve the Contractor of his responsibility to complete the Works by this date. The Contractor shall review the programme once each month to take account of any circumstances which arise affecting the progress of the Works, and shall produce a revised programme and submit copies to the Engineer.

A 34 CANCELLATION DUE TO SLOW PROGRESS

If the Engineer shall be of the opinion that having regard to the state of the Works at any time, the Contractor will be unable to complete any section of the Works by the time specified or by such extension thereof as he may be entitled to under the Contract and the Contractor has failed to carry out steps and to expedite the work in accordance with the Conditions of Contract or, if the Engineer is of the opinion that such steps are inadequate, the Engineer may, by written order omit the whole or any part of the uncompleted work included in that section and the Employer shall be at liberty to execute such omitted work by his own workman or by other Contractors. If the cost of such omitted or uncompleted work shall exceed the sum which would have been payable to the Contractor on the completion of the said work, then the Contractor shall, upon demand, pay to the Employer the amount of such excess and it shall be deemed a debt due by the Contractor to the Employer and shall be recoverable accordingly.
A 35  DELAYS

The Contractor will be deemed to have allowed for all delay caused by difficulty in obtaining labour and materials or by suspension of part or the whole of the Works due to adverse and inclement weather conditions.

A 36  NON-PRODUCTIVE TIME

The Contractor shall allow for all costs incurred by non-productive time and all other expenses in connection with overtime.

A 37  SAFETY, HEALTH AND WELFARE

The Contractor shall comply with enactments regulations and working rules relating to safety health and welfare of workpeople.

A 38  CONTRACTOR’S SITE REPRESENTATIVE

The Contractor’s Representative in charge of the Works shall be a duly graduated Engineer having at least Three (3) years experience in the superintendence of similar works and shall be required to have a proper command of the Arabic and English languages.

A 39  ATTENDANCE

The Contractor shall allow for and be responsible for the general attendance of one trade upon another.

A 40  OFFICIAL VISITORS

The Contractor shall at all times when authorized by the Engineer give free undisputed access and all facilities to any authorized employee of the Employer, any representative of the U.N.D.P. or any person authorized by the U.N.D.P. wishing to view or inspect any part of the Works or the materials to be incorporated therein.

A 41  CARE OF THE WORKS, ETC.

The Contractor shall keep all persons (including those employed by Sub-Contractors) under control and within the boundaries of the Site. He will be held responsible for the care of the existing premises and of the works generally until their completion, including all work executed and materials, good and plant (including those Sub-Contractors and Suppliers) deposited on the Site; together with all risks arising from the weather, carelessness of work people, damage or loss by theft or any other cause; and he shall make good at his own expense or such damage and lose.
A 42 WORK AT COMPLETION

The Contractor shall clean the Works thoroughly inside and out removing all splashes, deposits, rubbish and surplus material. The Contractor shall remove all temporary markings, coverings and protective rappings unless otherwise instructed.

The Contractor shall touch up minor faults in painted surfaces carefully matching colour and brushing out edges. He shall repaint badly marked areas back to suitable breaks and junctions.

The Contractor shall adjust, ease and lubricate all doors, windows, drawers hardware, equipment, appliances controls and other moving parts as necessary to ensure easy and efficient operations.

The Contractor shall leave the Works secure with all access locked. He shall account for all keys and shall hand over to the Employer with itemized schedule signed by the Employer as receipt.
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SECTION B
EXCAVATION - EARTH WORKS AND ROAD WORKS

B 1 GENERAL

The Contractor shall carry out all excavations, filling, backfilling and all other earthworks required in whatever material may be encountered.

The Works shall be executed accurately to the dimensions, levels, lines and profiles as indicated on the drawings or directed by the Engineer.

The Contractor shall reconstruct to the proper level and profile any filled areas which settle or spread during the execution of the work or during the maintenance period.

The Contractor shall drain and dewater the underground water to a level below the excavation by lowering the water table with a proper drainage and dewatering system approved by the Engineer.

B 2 SOIL INFORMATION

The Contractor shall be deemed to have visited the Site of Works and satisfied himself as to the nature of the ground and made himself conversant with the local conditions to be encountered during the execution of the Contract. The contractor is requested to perform a soil test to determine the nature and bearing capacity of the soil surface as directed by the Engineer.

B 3 MATERIALS

B 3.01 Backfill and Fill

Backfill and fill shall be a structurally sound material such as: less than 1 gravel or native soil free of rocks, lumps, vegetables and other organic materials obtained from suitable excavated material and/or from approved borrow pits.

B 3.02 Water

Water shall be clean potable water as specified under “Concrete Work”

B 3.03 Concrete

Concrete used as fill for making up the correct level areas of over-excavation shall be, where required by the Engineer of Class "B" as specified under "Concrete Work".
B 3.04  **Hardcore**

Hard-core under floor paving, etc... ) (Where shown on the drawings or as directed by the Engineer) shall consist of tough, sound and durable rubble stones (maximum 150mm), free from coatings, drys, seems or flows of any character. Fine aggregate for blinding the interstices of hard-core bed shall be as described in “Concrete Work”.

B 3.05  **Agricultural Soil, Gravel and Sand Fill**

Agricultural soil shall be first choice top soil rich in organic materials and free from roots, stones and rubbish suitable for plantation and shall be obtained from an approved source. Gravel fill shall consist of graded gravel 50mm. Down to 20mm. And blinded with clean coarse sand.

B 4  **SITE PREPARATION**

B 4.01  **Existing Public Utilities**

The Contractor shall ascertain the whereabouts of all existing public utilities on the site, both above and below ground. Such utilities shall be removed, sealed or rerouted in a manner prescribed by the Public Authorities concerned at the Contractor’s own expense. The Contractor shall also be held responsible for all damages entailed on any of the public utilities adjacent to the Site resulting from the Works.

B 4.02  **Removal of Existing Structures and Other Obstructions**

This work shall include, but not be limited to, the removal of existing structures and other obstructions interfering with the Works. The Salvaging of any of these materials for the use of the Employer shall be as directed by the Engineer and unwanted materials shall be disposed off the Site in a satisfactory Manner at the Contractor’s expense.

B 4.03  **Cleaning and Grubbing**

The Contractor shall perform the clearing and grubbing (if any) of top soil consisting mainly of loose soil, vegetable and organic matters, drift sand, unsuitable soil and rubbish by scarifying the areas to be excavated and side-walks to a minimum depth of 300mm from the natural ground level. All materials resulting from the above operations shall be removed from the Site, loaded and transported and off loaded spread and levelled to approved dumps as directed by the Engineer.


**SETTING-OUT**

The Contractor shall stakeout the work as shown on the Drawings and secure the Engineer’s approval of his stakeout before proceeding with construction. If, in the opinion of the Engineer, modification of the line or grade is advisable before or after stake-out the Engineer will issue detailed instructions in writing to the Contractor for such modification and the Contractor shall revise the stake-up for further approval in accordance with the relevant Clause of the Conditions of Contract.

**EXCAVATION**

**B 6.01 General**

Excavation in any material whatsoever found including rock to reduce levels and to form foundations, bases, trenches, septic tanks, cesspools, pits and the like to depths shown on the drawings or as directed by the Engineer.

Completely remove all existing obstructions in the line of excavations such as wall, slabs, curbs, steps and the like.

Trim excavations to required profiles and levels. Remove all loose material.

Level and well ram and consolidate surface of ground and bottom of all excavations to receive concrete foundations, beds, etc.

Bottoms of excavations shall be approved by the Engineer’s Representative before any concrete is laid.

Should the Contractor excavate deeper than is shown on the drawings or required by the Engineer’s Representative to obtain a solid bottom he must fill up excavation to the proper level with concrete Class B at his own expense.

**B 6.02 Excavation in Rock**

Rock shall be defined as boulders, exceeding 0.25m³ in volume or any kind of stone or rock formation which in the opinion of the Engineer’s Representative requires for its removal drilling and blasting wedging, sLEDging or barring or breaking up with power-operated hard tool.

The definition shall exclude any soft or disintegrated rock which can be removed with a hard pick or mechanical excavator or shovel or loose, shaken or previously blasted rock or broken stone in rock fillings or elsewhere.
Blasting by explosives shall not be permitted without obtaining the written approval of the Engineer. If such approval is given the Contractor shall be solely responsible for:

1. Obtaining permits, keeping record.
2. Storing permits, keeping record.
3. Taking all necessary precautions in compliance with the regulations pertinent to the use of Explosives.
4. Any damage that may occur due to the blasting operations where rock is encountered it shall be carefully excavated and the Contractor shall not be entitled to additional compensation unless otherwise specified in the Bills of Quantities.

PLANKING AND STRUTTING

The terms “planking and strutting” will be deemed to cover whatever methods the Contractor elects to adopt for shoring the sides of excavation and also for planking and strutting the excavations against the sides of adjoining buildings, public roadways, etc. The Contractor will be held responsible for shoring the sides of all excavations, adjoining building and the like and no claim for additional excavation, concrete or other material or workmanship will be considered in this respect.

In the event of any collapse occurring the excavations, the Contractor shall re-excavate and re-instate such excavations at his own expense. No additional excavations will be paid or should the Contractor batter the sides of the excavations.

KEEPING EXCAVATIONS FREE FROM WATER

All excavations shall be kept clear of water by pumping or bailing or by well-point dewatering, but the latter system shall not be employed if any danger exists of withdrawing water from the foundations of the adjoining buildings and such water shall be discharged clear of the works and the method adopted shall in no way contravene the regulations of the Local Authorities.

The system or systems to be employed shall be approved by the Engineer. Such approval if given shall not waive the Contractor’s responsibilities and liabilities under the Contract.

Particular attention shall be paid to the installation of sheeting and shoring as may be necessary for the protection of the work and for the safety of personnel and public.
**SPECIFICATIONS**

**EXCAVATIONS**

B 9  
**STORING OF SUITABLE EXCAVATED MATERIAL**

During excavation, materials suitable for backfill and fill shall be stockpiled on the Site at sufficient distance from the sides of the excavation to avoid overloading and prevent caveins or mixing with the concrete during the construction of foundations.

B 10  
**DISPOSAL OF UNSUITABLE AND SURPLUS EXCAVATED MATERIAL**

Upon the order of the Engineer, all unsuitable and surplus excavated materials shall be immediately removed. Loaded and transported off the site area by the Contractor to approved dumps and he shall abide by the relevant local regulations.

B 11  
**EXCAVATION FOR FOUNDATIONS AND SUB-STRUCTURE**

The Contractor shall excavate to reach a suitable strata accepted by the Engineer or as shown by the Drawings during excavation for foundations, the bottom layer of excavation of minimum 200mm in thickness, shall be left undisturbed and subsequently removed manually only when the concrete in blinding is about to be placed in order to avoid softening or deterioration of the surfaces of the excavation.

Bottom of all excavations shall be formed to correct levels as shown on the Drawings or as directed in writing by the Engineer and shall be trimmed, levelled and well cleaned before pouring and concrete.

In the event of the contractor excavating deeper than the levels required, he shall make the difference between levels with concrete class “B” at his own expense.

After each excavation is complete, the Contractor shall notify the Engineer to that effect, and no concrete shall be placed until the Engineer has approved the excavation and the character of the foundation material.

B 12  
**EXCAVATION FOR TRENCHES**

B 12.01  
**General**

The Contractor shall provide all forms and bracings, and excavate trenches necessary to install all drainage, sewer water supply, electrical and telephone cables to the lines and grades complete in strict conformity with these specifications, applicable drawings and/or as directed by the Engineer.
Grading

The bottom of the trenches shall be accurately graded to provide uniform bearing and support for each section of the pipe on undisturbed soil at every point along its length, except for the portions of the pipe where it is necessary to excavate for bell-holes and for proper sealing of joints. Bell-holes and depressions for joints shall be dug after the trench has been graded.

Share shall be taken not to excavate below the depths indicated. Where rock shall be excavated to the required depth. Uneven surface of the bottom trench shall be excavated 15mm deeper. Such depth, if in rock, shall be back-filled with concrete Class “B” as specified under “Concrete Work” and when in earth, shall be back-filled with approved sand at the Contractor’s own expense.

Whenever unstable soil, which in the opinion of the Engineer, is incapable of properly supporting the pipe or duct is encountered in the bottom of the trench, such soil shall be removed to the depth required and the trench back-filled to the proper grade with sand, fine gravel or other suitable material approved by the Engineer.

The width of the trench for Drainage at and below the top of the pipe shall be such that the clear space between the barrel of the pipe and the trench wall shall be 20mm on each side of the pipe. The width of the trench above that level may be as wide as necessary for sheeting and bracing and the proper performance of the work.

Trench for Water Supply System shall be of a depth to provide minimum cover over the top of 300mm and avoid interference of water lines with other utilities. Width of trench shall be a maximum of 200mm on each side of the pipe.

The width of trenches for electrical and telephone cables shall be as specified in their relative section. Banks may be sloped or widened to facilitate placement of cables, but not to an extend that will cause interference with other utilities.

Excavation for appurtenant structures for manholes, septic tank, percolating pit and similar structures shall be sufficient to allow a minimum of 300mm of clear space between their outer surfaces shoring timbers which may be used to protect the banks.
BACKFILL AND FILL

Approved suitable excavated material as specified under “MATERIALS” shall be used in the backfilling and filling next to footings, foundations underground structures, under sub-floors, etc... and shall be laid in layers not exceeding 200mm and compacted with compaction equipment, as approved by the Engineer. Moisture content shall be adjusted as directed by the Engineer and 95% of dry weight compaction accordance to ASTM: D1557-70 shall be achieved.

Should the quantity of the excavated material be not sufficient for the process of backfill and fill, the Contractor shall obtain the quantity required of such backfill and fill from approved borrow pits and transport same to the Site of work at his own expense.

No backfill shall be executed until the footings, foundations, etc., have been inspected, measured and approved by the Engineer.

Trenches should be backfilled until all required tests are performed and until the Engineer has verified that the Utility systems have been installed in accordance with the Specifications and the Drawings. The backfill in the pipe zone must be placed and completed so as to provide and maintain adequate and even support around the pipe wall. If mechanical compaction equipment is need, care must be taken to prevent direct contact with the pipe.

BED OF HARDCORE

The bed of hard-core, where shown on the Drawings or as directed by the Engineer shall be of an approved rubble stone as specified under "MATERIALS" and shall be laid under floor pavings. The rubble stone for hard-core shall be hand-packed with sharp edge upward and wider (natural face) laid on the ground. The interstices of hard-core bed shall be filled with approved fines, wetted sufficiently and well consolidated. The thickness of the hard-core bed shall be as shown on the Drawings.

PLACING OF AGRICULTURAL SOIL, GRAVEL AND SAND

The agricultural sifted soil as specified under "MATERIALS" shall be spread in the flower boxes and beds to the thickness shown on the Drawings after thorough watering and on a bed of 100mm thick graded gravel blinded with clean coarse sand to the satisfaction of the Engineer.
**EXCAVATIONS OF CUTTINGS IN CARRIAGE WAYS**

1- Hauling of material from cuttings or borrow pits to the embankments or other areas of fill shall proceed only when sufficient compaction plant is operating at the place of disposition to ensure compliance with the requirements of specifications.

2- Any excess depth excavated below formation level tolerance shall be made good by back filling with suitable material of similar characteristics to that removed, compacted in accordance with specification.

3- The slopes of cuttings shall be cleared of rock fragments which move when prized by a crow bar.

4- Construction traffic shall not use the surface of the bottom of a cutting unless the cutting is in rock or the Contractor maintains the level of the bottom surface at least 30cm above formation level. Any damage to the sub-grade arising from such use of the surface shall be made of good by the Contractor at his own expense, with material having the same characteristics as the material which has been damaged.

**FILLING AND FORMING OF EMBANKMENTS AND OTHER AREAS OF FILL**

1- Embankments and other areas of fill shall be formed of material defined as “suitable material”.

2- All earthworks material placed in or below embankments, below formation level in cuttings or else wherein the works shall be deposited and compacted as soon as practicable after excavation in layers of thickness appropriate to the compaction plant used or as a permitted departure therefrom. Embankments shall be built up evenly over the full width and shall be maintained at all times with a sufficient camber and a surface sufficiently even to enable surface water to drain readily from them. During the construction of embankments, the Contractor shall control and direct constructional traffic uniformly over their full width. Damage to compacted layers by constructional traffic shall be made good by the Contractor.

3- In areas of shallow filling where after removal of topsoil the ground level is within 30ccm of formation level constructional traffic shall not use the surface unless the Contractor brings up and maintains the surface level at least 30cm above formation level. Any damage to the sub-grade arising from such use shall be made good by the Contractor at his own expense with material having the same characteristics as the damaged materials.


**COMPACTION OF EMBANKMENTS AND OTHER AREAS OF FILL**

1- All materials used in embankments and as filling elsewhere shall be compacted as soon as practicable after deposition.

2- Variation from the method of compaction stated below or the use of plant not included therein will be permitted only if the Contractor demonstrates at site trials that a state of compaction is achieved by the alternative method equivalent to that obtained using the approved methods. This procedure shall be agree and approved by the Engineer.

3- The Engineer may at any time carry out comparative field density tests determined in accordance with S. S. 1377 test No. 14 on material, which he considers has been, inadequately compacted. If the test results when compared with the results of similar tests made on adjacent approved work in similar materials carried out in accordance with specification, show the state of compaction to be inadequate and this held to be due to failure of the Contractor to comply with the requirements of the Contract, the Contractor shall carry out such further work as the Engineer may decide is required to comply with the terms of the Contract.
5- The Contractor shall not less than 24 hours before he proposes to carry out compaction processes during periods of overtime, apply in writing to the Engineer for permission to do so.

B 19 ROAD WORKS

B 19.01 OVERALL REQUIREMENTS

A) Horizontal alignments, surface levels and surface regularity of pavement courses:

1- Horizontal alignments shall be determined from one edge of the carriage way pavement surface as shown on the Drawings. The edge of the carriageway as constructed and all other parallel alignments shall be correct within a tolerance of 15mm there from.

2- The levels of pavement courses shall be determined from the true pavement surface, which shall be the surface of the wearing course from flexible pavements calculated from the carriageway vertical profile and cross falls as shown on the Drawings. The vertical depth below the true pavement surface at any point on the constructed surface of the formation or pavement courses shall be within the appropriate tolerances stated below:

   Base course tolerance = __ 10 mm
   Road base tolerance = __ 15 mm
   Sub-base tolerance = __ 20 mm
   Formation tolerance = __ 25 mm

3- The surface level of the laid wearing course shall not deviate vertically at any point from the true pavement surface by more than 10mm.

4- For checking compliance with the above tolerances, measurements of surface levels will be taken at a grid of points 20 meter centers longitudinally and at 2 meter centers trans-versely starting one meter from the edge of the carriage way.

5- Compliance with tolerance shall be tested by rolling straight edge, operated parallel to the center line of the carriage way and one meter from the near side edge of each lane of carriage way.
6- For lengths less than 100 meter the laid pavement surface and the surface of the base course shall be tested with a 4 meter straightedge placed parallel to the centerline of the road. The laid pavement surface and the surface of the base course shall have no greater depression under the straightedge than 10mm and 10mm respectively.

7- Where any tolerance is exceeded the Contractor shall determine the full extent of the area which is out of tolerance and shall make good by rectifying the surface of the pavement course or formation in the manner described below:

a- Formation level:
If the surface is too high it shall be re-trimmed and re-compacted. If the surface is too low the deficiency shall be corrected by the addition of fresh suit-able material of the same classification laid and compacted to specification.

b- Roadbases and Sub-bases:
Where this consist of unbound material the top shall be scarified, reshaped, with added material as necessary, and recompacted all to specification. The area treated shall normally be not less than 30 meter long and 2.5 meter wide or such less length to be determined by the Engineer as necessary to obtain compliance with specification.

B) Use of surfaces by constructional traffic:
1- Constructional traffic used on pavement under construction shall be suitable in relation to the thickness of the courses it traverses so that damage is not caused to sub-grade or the material already constructed.

2- The wheels or tracks of plant moving over the various pavement courses shall be kept from deleterious materials.

C) Transporting, laying and compacting of road pavement materials containing Tar or Bitumen Binder.
1- Bituminous materials shall be transported in clean vehicles and shall be covered over when in transit or a waiting tripping. The use of dust, oil or water in the interior of the vehicles to facilitate discharge of the mixed materials is permissible but the amount shall be kept to a minimum and excess shall be removed by tipping or brushing.
2- The mixed material shall as soon as possible after arrival at the site be supplied continuously to the paver and laid without delay. The rate of delivery of material to the paver shall be so regulated as to enable the paver to be operated continuously and it shall be so operated whenever practicable.

3- The rate of travel of the paver and its method of operation shall be adjusted to ensure an even and uniform flow of material across the full laying width, freedom from dragging or tearing of the material and minimum segregation.

4- The material shall be laid generally in conformity with the recommendations for laying in the British Standard to which it has been made.

5- Hand laying of any bituminous material will be permitted only in the following circumstances:
   a. For laying regulating courses of irregular shape and varying thickness.
   b. In confined spaces where it is impracticable for a paver to operate.
   c. For footways.

6- Material shall be compacted as soon as rolling can be effected without causing undue displacement of the mixed material and while this has at least the minimum rolling temperature stated in the appropriate British Standard. The material shall be uniformly compacted by an 8-10 tons smooth wheel roller having a width of roll not less than 45cm, or by a mult-wheeled pneumatic tyred roller of equivalent weight except that wearing course and base course material shall be surface finished with a smooth wheel roller.

7- The material shall be rolled in a longitudinal carriageway over lapping on successive passes by at a pneumatic tyred roller, at least the nominal width of the tyre.

8- Hand-raking of wearing course material which has been laid by a paver and the addition of such material by handspreading to the paved area for adjustment of level will be permitted only in the following circumstances:
   a- At the edges of the layers of material and at gullies and manholes.
   b- Where otherwise directed by the Engineer.
EXCAVATIONS

9- Rollers shall not stand on newly laid material while there is a risk that it will be deformed thereby.

10- a. By heating the joint with an approved joint heater at the time when the additional width is being laid but without cutting back or coating with binder. The heater shall raise the temperature of the full depth or the wearing course to figure within the rolling temperature range specified for the material and for a width not less than 75mm on each side of the joint. In this case, however the Contractor shall have available for use in the event of breakdown, equipment necessary for operating method (c).

b. By using two or more pavers operating in echelon where there is practicable and in sufficient proximity for adjacent widths to be fully compacted by continuous rolling or by using a multiple-lane-width payer.

c. By cutting back the exposed joints to a vertical face of not less than the specified thickness, discarding all loosened material and cooling the vertical face completely with a grade of hot tar or hot bitumen suitable for the purpose before the next width is laid.

11- Base course material shall not remain uncovered by either the wearing course or surface treatment whichever is specified in the Contract for more than 3 consecutive days after being laid.

B 19.02 SUB-BASE AND ROAD BASE
A. Constructions requirements for materials of base and sub-grade.

1- Transport vehicles carrying plant mixed material shall have a capacity suited to the output of the mixing point and the site conditions and be capable of discharging cleany. Material when mixed shall be removed at once from the mixer, transported directly to the point where it is to be laid and protected from the weather both during transit from the mixer to the laying size and whilst tripping.
2. All material shall be placed and spread evenly. Spreading shall be undertaken either concurrently with placing or without delay. Roadbase material shall be spread using a paving machine or spreader box operated with a mechanism which levels off the material to an even depth. Except where otherwise specified in individual clauses, the material shall be spread in one layer so that after compaction the total thickness is as specified.

3. Compaction shall be completed as soon as possible after the material has been spread.

4. Special care shall be taken to obtain full compaction in the vicinity of both longitudinal and transverse.

5. The surface of any layer of material shall be on completion of compaction be well closed, free from movement under compaction plant and from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

6. Compaction shall be carried out by the method specified in the table page ()

B) Granular sub-base and Road Material:

1. It shall comprise natural sands, gravels, crushed rock. The material shall be well graded and lie within the following grading limits:

<table>
<thead>
<tr>
<th>B.S. Sieve Size</th>
<th>Percentage by weight passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 in</td>
<td>100</td>
</tr>
<tr>
<td>1 1/2 in</td>
<td>85 - 100</td>
</tr>
<tr>
<td>3/8 in</td>
<td>45 - 100</td>
</tr>
<tr>
<td>3/16 in</td>
<td>25 - 85</td>
</tr>
<tr>
<td>No. 25</td>
<td>8 - 45</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 - 10</td>
</tr>
</tbody>
</table>

The particle size shall be determined in accordance with B.C. 1377.

2. The material passing no. 36B.S. sieve, when tested in accordance with B.S. 1377 shall have a plasticity index of less than 6.
SPECIFICATIONS

EXCAVATIONS

3- The material shall be laid and compacted to the requirements of specifications at a moisture content within the range one percent above to 2 percent below the optimum percentage determined in accordance with vibrating hammer method test in B.S. 1377.

4- On completion of roadbase and until any surfacing is laid on it, the finished surface shall be maintained free from potholes, ruts and undulations, irregularities depressions, loose material or other defects.

5- Paved hard shoulders shall be constructed of the materials and to the dimensions described in the contract. Alternatively if agreed by the Engineer the Contractor may construct hard shoulders to the same specification as the carriage way pavement.

B 19.03 FLEXIBLE SURFACING

A) Rolled Asphalt for Base:
   1- This material shall be made in accordance with the requirements of B.S. 594 for base course mixtures subject to the under mentioned proviso relating to blastfurnace slag. It shall be laid and compacted to relevant clauses.
   2- Coarse aggregate content 65 percent. When the bulk density of the slag coarse aggregate is less than 80lb per cubic foot, the coarse aggregate content shall be reduced to 55 per cent.
   3- Petroleum bitumen in accordance with B.S. 594 of penetration as described in the contract.

B) Rolled Asphalt Wearing Coarse:
   1- Rolled asphalt wearing coarse shall be in accordance with the general requirements of B.S.594.
   2- Asphalitic Cement:
      a. Equal proportions by weight of petroleum bitumen of appropriate penetration and reind asphalt or/
      b. Pitch/Bitumen to the following specifications: A mixture of 75-80 percent of petroleum bitumen with 20-25 percent of a coal tar pitch produced by straight running predominately from a vertical retort crude source.
The softening point of the pitch shall lie between 55 C and 80 C and the petroleum bitumen shall have a penetration conforming to the requirements of B.S.594 tables 1, 2 or 3 as described in the Contract. The Engineer may require, from time to time, certificates confirming that the mixture has a salability index not higher than 1.2 when tested according to the method described in the Road Research Laboratory Research Note No. RN/4112. The use of density-gradient column in a storage stability test for pitch/bitumen mixtures; or

c. Petroleum Bitumen.

3- Content of coarse aggregate for new works 3 percent by weight.

4- Binder Content/ Bulk of Blastfurnace Slag Relationship.

When the coarse aggregate is blastfurnace slag the binder content shall be related to the bulk density of the aggregate. When the bulk density is less than 87lb per cubic foot (1400Kg/M3) rounded to the nearest 1 lb per cubic foot (16Kg/M3) the soluble bitumen content shown in the following table:

<table>
<thead>
<tr>
<th>Coarse Aggregate retained on No. 7 B.S. Sieve</th>
<th>Aggregate passing Soluble binder</th>
<th>Aggregate passing No.200 B.S. Sieve</th>
<th>Aggregate passing No. 7 and retained on No. 200 B.S.</th>
<th>Percentage by weight of total mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crushed rock</td>
<td>Min. 30</td>
<td>Max. 7.9</td>
<td>Min. 10.9</td>
<td>Max. 50.9</td>
</tr>
<tr>
<td>Blast-furnace slag</td>
<td>7.9</td>
<td>8.9</td>
<td>8.9</td>
<td>10.9</td>
</tr>
</tbody>
</table>

Shall be increased as shown below in the table and the percentage of aggregate passing the No.7 B.C. Sieve and retained on the No. 200 B.S. Sieve correspondingly reduced. Slag having a bulk density of less than 68lb per cubic foot shall not be used.

<table>
<thead>
<tr>
<th>Bulk density of slag Lb/ft3</th>
<th>Addition to specified percentage of soluble bitumen content</th>
</tr>
</thead>
<tbody>
<tr>
<td>87 and above</td>
<td>New Works Nil</td>
</tr>
<tr>
<td>81-86</td>
<td>Resurfacing Depending on the coarse aggregate content specified</td>
</tr>
<tr>
<td>74-80</td>
<td>0.1</td>
</tr>
<tr>
<td>68-73</td>
<td>0.2</td>
</tr>
<tr>
<td>68-73</td>
<td>0.3</td>
</tr>
</tbody>
</table>
C) Bituminous Sprays:

1- When it is necessary to prepare a surface for the application of a bituminous spray and to undertake the spraying and any specified binding, this shall be done in accordance with the recommendation of the Ministry of Transport Road notes relating to surface dressing in so far as they apply to work to be undertaken. The work shall also be undertaken in accordance with the under-mentioned general requirements and any specific requirements as described in the Contract.

2- The Engineer may require the contractor to provide a certificate stating that a particular binder distributor has been tested since the previous surface dressing season and that the test indicates conformity of the requirements for B.S.1707 for hot binder distributors or with the requirements of B.S. 3236 for emulsion distributors.

3- Before spraying is commenced, the surface shall be freed of all loose material. The surface as a whole shall be dry and any damp areas shall be completely free from standing water.

4- Binding material, where required by the contract, shall consist of a commercial grade of hard clean crushed rock or slag fine aggregate or sand; it shall contain not more than 15 percent retained on a ¼ inch B. S. Sieve.

5- Unless the Engineer permits otherwise, all loose material on the sprayed surface, including any building material, shall be removed before any further layer of the pavement is laid.

B 19.04 SIGNS AND ROAD MARKINGS

A) Permanent Traffic signs and information signs:

1- Permanent traffic signs shall be either externally or internally illuminated, reflecting or non-reflecting as described in the Contract and the local standards.

2- Where illumination is to be provided, this shall be by lamps of tungsten filament or fluorescent type complying with B.S. 873 Where reflectorisation is required the means shall be of approved type as all as described in the Contract.

3- Signs shall be erected with approved fittings on posts made from rectangular or tubular steel. The construction and supports of large signs shall be as described in the Contract.
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<th>Tiles</th>
<th>Page No.</th>
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</thead>
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<td>C - 14</td>
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<td>3 - 57</td>
</tr>
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<td>C = 15</td>
<td>Monolithic smooth finish surfaces</td>
<td>3 - 58</td>
</tr>
</tbody>
</table>
SECTION C

CONCRETE WORK

C 1 SCOPe

This section describes and specifies work required for plain and reinforced concrete, including formwork intended to be used for the Project under the Contract in accordance with the Drawings, Bills of Quantities and as directed by the Engineer.

At the beginning of each month, the Contractor shall submit to the Engineer his concreting programme for that month, stating the pouring dates, so that adequate checking and supervision can be provided before and during the pouring operation. No pouring shall be allowed unless the Engineer has been given a week-advanced notice of the intention to pour.

C 2 APPLICABLE TESTS AND CODES

Prior to commencement of concrete work, the Contractor shall submit samples to the Engineer before sending them to the laboratories for testing, to establish the probability of the materials passing tests for specified requirements.

After the Engineer is convinced that the samples with their sources are truly representative samples and sufficient materials are available on the Site for the completion of all concrete works under the Contract, the samples shall be approved and sent to the laboratories for testing. Upon the Engineer’s request, the Contractor shall have the tests made, at his own expense in the laboratories approved by the Engineer.

All concrete aggregates, cement and water shall be sampled and tested as frequently as deemed necessary by the Engineer. All tests samples shall be obtained in accordance with the latest editions of the American Society for Testing and Material (ACI) Code or any equally approved standard.
C 3 MATERIALS

C 3.01 Cement

(A) General

Cement shall be Portland Type originating from approved manufacturers in sealed and labelled bags, each 50 kgs. Not capacity, name and brand of the manufacturer shall plainly be identified thereon and Delivered to the Site in good condition Cement delivered in bulk shall be accepted only if a central mixing plant is used. The Quality of cement shall conform to the Standard Specification for PORTLAND CEMENT of ASIM Designation: C150-74 Type I- for use in general concrete construction and Type V- for use when high sulphate resistance is desired.

(B) Storage of Cement

All cement shall be stored in suitable weatherproof and approved storage sheds which will protect the cement from dampness. Storage sheds shall be erected in locations approved by the Engineer. Provision for storage shall be ample, and the consignment of cement as received shall be separately stored in such a manner as to provide easy access for the identification and inspection of each consignment Cement shall be used in the order of its delivery to site, new deliveries shall not be used unless the cement from earlier deliveries has been completely used. Stored cement shall meet the test requirements at any time after storage when a re-test is ordered by the Engineer all the expense of the Contractor.

The Contractor shall keep accurate records of the deliveries of cement and of its use in the work. Copies of these records shall be supplied to the Engineer in such form as may be required.

(C) Rejection

The Contractor shall notify the Engineer of dates of delivery so that there will be sufficient time for sampling the cement either at the mill or upon delivery.

The provisional acceptance of the cement at the mill shall not deprive the Engineer of the right to reject on a reset of soundness at the time of delivery of the cement to the Site.
Package of cement varying by 5 percent or more from the specified weight shall be rejected and if the average weight of packages in any consignment, as shown by weighing 50 packages taken at random, is less than that specified, the entire consignment shall be rejected and the Contractor shall remove it forthwith from the Site at his own expense and replace it with cement of satisfactory quality. Stale cement or cement reclaimed from cleaning bags shall not be used and cement which for any reason has become partially set, or contains lump or caked cement, shall be rejected.

C 3.02 Aggregates

(A) General Requirements
All aggregates shall consist of tough, hard, durable uncoated particles. The Contractor shall be responsible for the processing of this material to meet the requirements of the Specifications. Approval of aggregate quality and/or gradation shall not waive the responsibility of the Contractor to provide concrete of having the minimum strength specified.

(B) Storage
Coarse and fine aggregates shall be delivered and stored separately on site in such a manner as to prevent segregation and contamination or the admixture of foreign materials. Aggregate which has become segregated or contaminated with foreign matter during storage or handling will be rejected and shall be removed and replaced with material of acceptable quality at the Contractor’s expense. Aggregates of the quality and colour selected shall be stored in sufficient quantity to avoid interruption of concreting work at any time.

C 3.03 Fine Aggregate

(A) General Requirements
All fine aggregate shall conform to Standard Specification for Concrete Aggregates of ASIM Designation: C-33 and also to the detailed requirements given in Table 300 A (appendix herebelow). It shall not contain harmful materials such as iron pyrites, coal, mica, and shale. Alkali, coated grains, or similar laminated materials such as soft and flaky particles, or any material which may attack the reinforcement, in such a form and in sufficient quantity to affect adversely the strength and durability of the concrete. Fine Aggregate passing sieve No. 4 shall not contain any voided shells. Fine aggregates shall be washed thoroughly with demineralized water to ensure compliance with the appropriate requirements and limitations of the specifications.
The Contractor shall provide and maintain for this proposes sand-washing plant and equipment.

Fine Aggregate from different sources of supply shall not be mixed or stored in one pile nor used alternately in the same class of construction or mix.

Table 300 A

<table>
<thead>
<tr>
<th>Grading</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve</td>
<td>Passing</td>
</tr>
<tr>
<td>3/8</td>
<td>100</td>
</tr>
<tr>
<td>No. 4</td>
<td>95 - 100</td>
</tr>
<tr>
<td>8</td>
<td>80 - 100</td>
</tr>
<tr>
<td>16</td>
<td>50 - 85</td>
</tr>
<tr>
<td>30</td>
<td>25 - 60</td>
</tr>
<tr>
<td>50</td>
<td>10 - 30</td>
</tr>
<tr>
<td>100</td>
<td>2 - 10</td>
</tr>
<tr>
<td>200</td>
<td>0 - 3</td>
</tr>
</tbody>
</table>

Fineness modulus

2.50-2.15

Organic Impurities

The color shall have an intensity not darker than two-thirds the intensity of the standard color solution. (Not darker than Plate 2 as determined by the Standard Method of Test for Organic Impurities in Sands for Concrete of ASTM Designation C - 40

Chlorides soluble in dilute Nitric Acid

Not more than 0.10 percent by weight when expressed as sodium chloride (NACL).

Total Acid soluble sulphates

Not more than 0.50 percent by weight when expressed as sulphur trioxide (S03)

Silt

Not more than 2 percent

Mortar strength

Compression ratio not less than 95 percent.

Soundless

Weighted average loss when subjected to 5 cycles of the soundless test using magnesium sulfate, not more than 10 percent.
C 3.04 Coarse Aggregate

(A) General Requirements

All coarse aggregate for concrete shall conform to Standard Specifications for Concrete Aggregates of ASTM Destination: C-33. Coarse aggregate shall consist of gravel, crushes gravel, or crushed stone, having hard, strong durable pieces, free from adherents. It shall not contain harmful materials such as iron pyrites, coal, mica, alkali, laminated materials, or any material which may attack the reinforcement, in such a for or in sufficient quantity to affect adversely the strength and durability of the Concrete. Coarse aggregates shall be washed thoroughly with demineralized water to ensure compliance with the appropriate requirements and limitations of the specifications. The Contractor shall provide and maintain for this purpose approved washing plant and equipment.

(B) Deleterious Substances

The amount of deleterious substances shall not exceed the following limits:

<table>
<thead>
<tr>
<th></th>
<th>Max. Permissible Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent by Wt.</td>
</tr>
<tr>
<td>Soft fragments</td>
<td>2.0</td>
</tr>
<tr>
<td>Coal and lignite</td>
<td>0.5</td>
</tr>
<tr>
<td>Clay lumps</td>
<td>0.25</td>
</tr>
<tr>
<td>Materials passing the No.200 sieve</td>
<td>1.0</td>
</tr>
<tr>
<td>Thin or clognated pieces(length greater than 5 times average thickness)</td>
<td>4.0</td>
</tr>
<tr>
<td>Other local deleterious substances</td>
<td>0</td>
</tr>
<tr>
<td>Chlorides soluble in dilute Nitric acid when expressed as Sodium Chloride (NaCL)</td>
<td>0.05</td>
</tr>
<tr>
<td>Total acid soluble sulphates when expressed as sulpher trioxide (S03)</td>
<td>0.5</td>
</tr>
</tbody>
</table>

(C) Percentage of Wear

Coarse aggregate shall conform to the following requirements:
Percentage of wear, Los Angeles test, not more than ................ .......................... 30
(D) Grading

Coarse aggregate, when tested according to the requirements of ASTM, shall meet the following gradation and shall be uniformly graded within the limits stated in Table 1 herebelow:

Table 1

<table>
<thead>
<tr>
<th>ASTM Passing</th>
<th>Grading (3/4&quot; to No.4)</th>
<th>Grading (1&quot; to No.4)</th>
<th>Grading (2&quot; to No.4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 1/2 inch</td>
<td>-</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>2 inch</td>
<td>-</td>
<td>-</td>
<td>95 - 100</td>
</tr>
<tr>
<td>1 1/2 inch</td>
<td>-</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>1 inch</td>
<td>100</td>
<td>95 - 100</td>
<td>35 - 70</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>95 - 100</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1/2 inch</td>
<td>-</td>
<td>25 - 60</td>
<td>10 - 30</td>
</tr>
<tr>
<td>1/3/8 inch</td>
<td>20 - 55</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>No. 4</td>
<td>0 - 10</td>
<td>0 - 10</td>
<td>0 - 5</td>
</tr>
<tr>
<td>No. 8</td>
<td>0 - 5</td>
<td>0 - 5</td>
<td>-</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 - 1</td>
<td>0 - 1</td>
<td>0 - 1</td>
</tr>
</tbody>
</table>

(E) Combined Aggregate

Approved fine and coarse aggregate on each batch of concrete shall be combined in proportions as approved by the Engineer, according to test results giving the required compressive concrete stress as specified per type of Concrete.

The combined aggregate gradation using the ¾ in. to No. 4 gradation shall be used for concrete members with reinforcement to close or permit proper placement and consolidation of the concrete. Change from one gradation to another shall not be made during the progress of the work unless approved by the Engineer. Such changes are admitted only after being proved by test results.

C 3.05 Aggregate for Mortar

(A) General Requirements

Aggregate for motor shall conform to the Standard Specification for Aggregate for Masonry Mortar of ASTM Designation: C-144 and shall consist of hard, strong, durable uncoated mineral or rock particles, free from injurious amounts of organic or other deleterious substances.
SPECIFICATIONS
CONCRETE WORK

(B) Organic Impurities

Fine aggregate for mortar when subjected to the Calorimetric test for organic impurities and producing a color darker than the standard color shall be rejected.

C 3.06 Water

(A) Quality of Water

Water for mixing of concrete shall be fresh, clean and free from injurious amounts of oil, acid, or any other deleterious mineral and/or organic matter. It shall not contain chlorides such as sodium chloride in excess of 700 ppm. It shall not contain any impurities in amount sufficient to cause a change in the time of setting of Portland Cement of more than 10 percent, nor a reduction in compressive strength of mortar of more than 5 percent compared to results obtained with distilled water.

The PH of the water for mixing and curing of concrete shall not be less than PH 4.5 or more than PH 8.5.

(B) Tests for Water

When required by the Engineer the quality of the mixing water shall be determined by the Standard Method of Test for quality of water to be used in concrete, as specified in B.S. 3148: 1959 Tests for Water for Making Concrete.

In sampling water for testing, care shall be taken to ensure the containers are clean and that samples are representative.

C 3.07 Admixtures

Admixtures in concrete shall be used only when approved by the Engineer and shall conform to the requirements of the ASTM Standard Specifications Designation C-494-68 for Water Reducing and Retarding Admixtures, and C-260-69 for Air entraining Admixtures for Concrete, and waterproofing and watertightening.

The Contractor shall ensure that the admixture supplied for use in the work is equivalent in composition to the admixture subjected to test under this Specification. Tests shall be made whenever practicable using the cement, aggregates, admixtures proposed for specific work, because The specific effects produced by chemical admixtures may vary with the properties of the other ingredients of the concrete.
The specific effects produced by chemical admixtures may vary with the properties of the other ingredients of the concrete.

Admixture that contain relatively large amounts of chloride shall accelerate corrosion of reinforcing steel and shall be the cause of rejection.

Water reducing and retarding admixtures shall comply with the physical requirements of ASTM tests and shall be approved in writing by the Engineer.

When the admixture is delivered in packages or containers, the proprietary name of the admixture, the type and the weight or volume shall be plainly marked thereon. Similar information shall be provided in the shipping advises accompanying packaged or bulk shipments of admixtures.

The admixture shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment, and in a suitable weather-tight stores that will protect the admixture from dampness.

Costs of such admixtures, sampling and testing shall be at the Contractor’s expense.

**COMPOSITION OF CONCRETE**

The cement content, coarse aggregate size, water content, consistency and the approximate weights of fine and coarse aggregate (saturated surface-dry basis) for the class of concrete shall be within the requirements of Table I and II Below.

The weight of fine and coarse aggregate given in Table II below are based on the use of aggregates having bulk specific gravities, in a saturated surface-dry condition, 2.65-5%. For reasonably well graded materials of normal physical characteristics, the use of the below indicated proportions, together with specified water content to obtain the required consistency, will result in concrete of the specified cement content, plus or minus two (2) percent.

For aggregate having specified gravities outside the ranges indicated in the Table II below, the weights shall be corrected by multiplying the weights shown in Table II below by the ration of the specific gravity of the aggregate and 2.65.
The relative weights of fine and coarse aggregate per sack of cement given in Table II below are based on the use of natural sand having a fineness modulus within the range of 2.70 and 2.90 and methods of placing which do not involve high frequency vibration. When sharp, angular manufactured sands, or extremely coarsely graded sands are used, the relative amount of fine aggregate should be increased. For finer sands the relative amount of fine aggregate should be decreased. In general, the least amount of sand which will insure concrete of the required workability for the placing conditions involved should always be compensated for by changing the weight of coarse aggregate in the opposite direction by a corresponding amount.

**Table I**

<table>
<thead>
<tr>
<th>Class of Concrete</th>
<th>Compressive Strength At 28 Days (in Kg/cm²)</th>
<th>Minimum Cement Content Kgs</th>
<th>Coarse Aggregate Size</th>
<th>Max. Water Content Kgs</th>
<th>Consistency Range in Slump Vibrated Liters</th>
<th>- Non Vibrated Per Bag</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>250</td>
<td>375</td>
<td>3/4in.or 1in.-No.4</td>
<td>27</td>
<td>50-100</td>
<td>75-125</td>
</tr>
<tr>
<td>B</td>
<td>200</td>
<td>350</td>
<td>Ditto</td>
<td>27</td>
<td>50-100</td>
<td>33-125</td>
</tr>
<tr>
<td>C</td>
<td>150</td>
<td>250</td>
<td>2in.-No 4</td>
<td>30</td>
<td>25-50</td>
<td>50-75</td>
</tr>
</tbody>
</table>

**Table II**

<table>
<thead>
<tr>
<th>Class of Concrete</th>
<th>Compressive Strength At 28 Days Kg/cm²</th>
<th>Approximate Weight (Saturated Surface-Dry) of Fine and Coarse Aggregate Per Sack (50Kgs) of Cement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Rounded Coarse Aggregate Kgs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fine</td>
</tr>
<tr>
<td>A</td>
<td>250</td>
<td>40</td>
</tr>
<tr>
<td>B</td>
<td>210</td>
<td>95</td>
</tr>
<tr>
<td>C</td>
<td>140</td>
<td>140</td>
</tr>
</tbody>
</table>

Table II is given for indicative purposes and is not binding.
The total sodium chloride content of any materials used for making concrete shall be less than:
- For mass concrete ............... 1.5 percent
- For reinforced concrete ....... 0.7 percent

Expressed as a percentage, by weight of the cement. In calculations made under the provisions of this clause, any chloride, other than sodium chloride in the materials shall be converted to the equivalent of sodium chloride and be added to the amount of sodium chloride. The sulphate content shall not exceed 0.03 percent by weight of the cement.

C 5

PROPORTIONS

C 5.01 General

After the materials provided by the Contractor have been accepted for the works, the proportions and equivalent batch weights shall be determined which will produce concrete having not less than the strength required.

C 5.02 Trial Mixes

The actual proportions shall be determined on the basis of trial mixes made by the Contractor and conducted with the content being determined by means of yield test in accordance with American Society for Testing Material (ASTM) Designation (C-138). The proportions will be such as to required (within a tolerance of plus or minus one (1) percent, the cement content shown in Table I as the minimum cement content, provided, however, that if the materials supplied by the Contractor are of such a nature or are so graded that proportions based on the minimum cement content cannot be used without exceeding the maximum allowable water content specified in Table I, the proportions will be adjusted so as to require the least amount of cement which will produce concrete of the required plasticity and work-ability without exceeding such maximum allowable water content. No additional compensation will be made for the increase in quantity of cement required.

C 5.03 Contents

The mixes required will be designated in kilograms of fine and coarse aggregate exclusive of free water, per sack (50 Kilograms) of cement and in liters of total mixing water per sack of cement on the basis of the required amount of cement per cubic meter of concrete.
C 5.04 Batch Weights

Since the proportions are designated in terms of aggregate in surface-dry condition, the equivalent batch weights to be used in the work shall be corrected periodically to take into account the actual moisture content of the aggregates at the time of use.

C 6 CONCRETE COMPRESSION AND SLUMP TESTS

C 6.01 Cubical Test

The Compression Strength of Concrete shall be obtained according to cubical tests locally done. Test cubes made in the field shall have a dimension of 10 cm, At least 3 separate batches of concrete shall be made for trial and these shall be tested for compliance with the requirements of the table below, at least 3 test cubes being made from each batch of concrete. Once a mix is approved no substantial change in the materials or proportions of materials being used shall be made without the approval of the director of works who may then require further trial mixes to be produced. The compressive strength of the concrete will be taken as the arithmetic mean of the strength of all the cubes tested.

The following table will be used to compare test results:

<table>
<thead>
<tr>
<th>Kind of Concrete</th>
<th>Mean value at 28 days Kg / cm²</th>
<th>Minimum Individual Value at 28 days Kg / cm²</th>
<th>Mean value at 28 days Kg / cm²</th>
<th>Minimum Individual Value at 28 days Kg / cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>B - 150</td>
<td>190</td>
<td>130</td>
<td>180</td>
<td>120</td>
</tr>
<tr>
<td>B - 200</td>
<td>240</td>
<td>180</td>
<td>230</td>
<td>170</td>
</tr>
<tr>
<td>B - 300</td>
<td>340</td>
<td>280</td>
<td>330</td>
<td>270</td>
</tr>
</tbody>
</table>

Table of Compressive Strength results of samples of concrete at 28 days. (Mixed by Weight)
C 6.02 Slump Tests
Slump tests shall be carried out periodically to ensure the appropriate water cement ratio in accordance with the Standard Method of Test of Slump of Portland Cement Concrete of the ASTM Designation: C-143.

C 6.03 Test of Hardened Concrete in the Structure
Where the results of specimens indicate that the concrete does not meet specification requirements, core boring tests conforming to the current issue of ASTM Designation: C-42 shall be performed, as directed by the Engineer, all at the Contractor’s expense.

C 7 MEASUREMENT OF MATERIALS
Materials shall be measured by weight, except as otherwise specified or where other methods are specifically authorized by the Engineer. The apparatus provided for weighing the aggregates and cement shall be suitably designed and constructed for this purpose. Each size of an aggregate and the cement shall be weighed separately. The accuracy of all weighing devices shall be such that successive quantities can be measured to within 1% of the desired amount. Cement in standard packages (sack) need not be weighed. The mixing water shall be measured by a measuring device susceptible of control accurate to plus or minus half percent of the capacity of the tank but not exceeding 2 liters. All measuring devices shall be subject to the Engineer’s approval.

Where volumetric measurements are exceptionally authorized by the Engineer for projects where the amount of concrete is small, the weight proportions shall be converted to equivalent volumetric proportions. In such cases, suitable allowance shall be made for variations in the moisture condition of the aggregates, including the bulking effect in the fine aggregate.

C 8 MIXING OF CONCRETE
C 8.01 General
Unless otherwise authorized by the Engineer, concrete shall be machine mixed.

The mixing of concrete or mortar shall not be permitted when the temperature is above 40 °C or when the temperature is below 5 °C.
Concrete shall be thoroughly mixed in a batch mixer conforming to the requirements of B.S. 1305 Batch type concrete mixers which will ensure a uniform distribution of the materials throughout the mass.

The mixer shall be equipped with adequate storage and a device for accurately measuring and automatically controlling the amount of water used on each batch. Preferably mechanical means shall be provided for recording the number of revolutions for each batch and automatically preventing the discharge of the mixer until the materials have been mixed within the specified minimum time.

The entire contents of the mixer shall be removed from the drum before materials for a succeeding batch are placed therein.

All concrete shall be mixed for a period of not less than 1 ½ minutes after all materials, including water, are in the mixer. During the period of the mixing the mixer shall operate at the speed for which it has been designed, but this speed shall be not less than 14 nor more than 20 revolutions per minute.

The first batch of concrete material placed in the mixer shall contain sufficient excess of cement, sand and water to coat the inside of the drum without reducing the required mortar content of the mix. Upon the cessation of mixing for a considerable period, the mixer shall be thoroughly cleaned.

Truck mixers, unless otherwise authorized by the Engineer, shall be of the revolving drum type, watertight, and so constructed that the concrete can be mixed to ensure a uniform distribution of materials throughout the mass. All solid materials for the concrete shall be accurately measured in accordance with Section C.7 and charged into the drum at the proportioning plant. Except as subsequently provided, the truck mixer shall be equipped with a tank for carrying mixing water. Only the prescribed amount of water shall be placed in the tank unless the tank is equipped with a device by which the quantity of water added can be readily verified. Truck mixers may be required to be provided with means by which the mixing time can be readily verified by the Engineer.
The maximum size of batch in truck mixers shall not exceed the maximum rated capacity of the mixer as stated by the manufacturer and stamped in metal on the mixer. Truck mixing shall be continued for not less than 50 revolutions after all ingredients including the water, are in the drum. The speed shall not be less than 4 r.p.m., nor more than a speed resulting in a peripheral velocity of the drum of 70 meters per minute.

Nor more than 100 revolutions of mixing shall be at speed in excess of 6 r.p.m. Mixing shall begin within 30 minutes after the cement has been added either to the water or aggregate. When cement is charged into a mixer drum containing water or surface-wet aggregate and when the temperature is above (33°C) is used this limit shall be reduced to 1245 minutes; the limitation on time between the introduction of the cement to the aggregates and the beginning of the mixing may be waived when, in the judgement of the Engineer, the aggregates are sufficiently free from moisture, so that there will be no harmful effects on the cement.

C 8.04 Partial mixing at the Central Plant

When a truck mixer provided with adequate mixing blades is used for transpiration, the mixing time at the mixing plant may be reduced to 30 seconds and the mixing completed in the truck mixer. The mixing time in the truck mixer shall be as specified under the Section C.8.3 for truck mixing.

C 8.05 Plant Mix

Mixing at a central plant shall conform to the requirements for mixing at the Site and shall conform to the applicable requirements of the Standard Specification for Ready-Mixed Concrete of ASTM Designation: C-94.

C 8.06 Time of Hauling and Placing Concrete

If the distance from the mixing plant to the construction Site is so great that between the time of mixing and pouring the concrete, the temperature is below 40°C and the travelling time is more than 30 minutes, truck mixers must be employed.

When truck mixers are used, concrete shall be discharged and placed in its final position in the forms within thirty (30) minutes after water is first added to the mix.
C 8.07  
**Delivery**

The rate of delivery of concrete during concreting operations shall be such as to provide for the proper handling, placing and finishing of the concrete. The rate shall be such that the interval between batches shall not exceed 20 minutes. The methods of delivering and handling the concrete shall be such as will facilitate placing with the minimum of rehandling and without damage to the structure of the concrete.

C 8.08  
**Retempering**

The concrete shall be mixed only in such quantities as are required for immediate use and any concrete which has developed initial setting shall not be used. Concrete which has partially hardened shall not be retempered or remixed.

C 9  
**HANDLING AND PLACING CONCRETE**

C 9.01  
**General**

Prior to pouring concrete in any structure, the Contractor shall secure a written order to commence from the Engineer. In preparation for the placing of concrete all sawdust, chips, and other construction debris and extraneous matters shall be removed from the interior of forms, structs, stays and braces, serving temporarily to hold the forms in correct shape and alignment, pending the placing of concrete placing has reached an elevation rendering their service unnecessary. These temporary members shall be entirely removed from the forms and not buried in the concrete. Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. The use of long troughs, chutes and pipes for conveying concrete from the mixer to the forms shall not be permitted unless the authorization in writing of the Engineer is obtained. In case an interior quality of concrete is produced by the use of such conveyers, the Engineer may order discontinuance of their use and the substitution of a satisfactory method of placing. Open troughs and chutes shall be of metal lined and shall be of rounded cross section to avoid the accumulation of concrete in corners. The chutes shall be equipped with baffles or be in short lengths that reverse the direction of movement. The slope shall be steep enough (1 vertical to 2 or 2 ½ horizontal) to permit flow requiring a slump greater than specified or required for placement.
All chutes, troughs and pipes shall be kept clean and free from coating of hardened concrete by thoroughly flushing with water after each run. Water used for flushing shall be discharged clear of the structure. When placing operations would involve dropping the concrete more than 1.50 meter, it shall be deposited through sheet metal or other approved pipes. As far as practicable, the pipes shall be kept full of concrete during placing and their lower ends shall be kept buried in the newly placed concrete. After initial setting of concrete, the forms shall not be jarred and no strain shall be placed on the ends of reinforcement bars which project.

C 9.02 Hot Weather Concreting

The temperature of concrete when placed shall not exceed 27°C. When the relative humidity is 50 percent or less and shall not exceed 32 ºC. For values of relative humidity between 50 percent and 70 percent, the max temperature of concrete shall be found by interpolation.

In lieu of above, the temperature of concrete when placed shall not exceed 32 ºC, regardless of the relative humidity.

The Contractor shall comply with the above requirements by the following procedures:

- Cooling the mixing water and/or replacing 50% of the mixing water by crushed ice. When crushed ice is used it shall be stored at a temperature that will prevent formation of lumps. The ice shall be completely melted by the time mixing is completed.

- Shading aggregate stockpiles and/or keeping moist by sprinkling then with water.

- Cement shall not be used if its temperature exceeds 77 ºC.

- Painting the mixer drum white and spraying it with cool water or shading the mixer from direct sunrays.

- Maintaining the mixing time and delivery time to the minimum acceptable.

- Sprinkling of forms sub-grade and reinforcement with cool water prior to placement of concrete.

Water reducing and retarding admixture shall be used in all concrete work when the temperature of concrete exceeds 27 ºC. The water cement ratio inclusive of free surface moisture on aggregates and any admixtures shall be kept to a minimum.
C 9.03 Vibrating Concrete

Concrete, during and immediately after depositing, shall be thoroughly compacted. The compaction shall be done by mechanical vibration subject to the following provisions:

- Vibration shall be internal unless special authorization of other methods is given by the Engineer or as provided herein.

- Vibration shall be of a type and design approved by the Engineer. They shall be capable of transmitting vibration to the concrete at frequencies of not less than 4500 impulses per minute.

- The intensity of vibration shall be such as to visibly affect mass concrete of 25mm slump.

- Contractor shall provide a sufficient number of the vibrators to properly compact each batch immediately after it is placed in the forms.

- Vibration shall be manipulated so as to thoroughly work the concrete around the reinforcement and embedded fixtures, and into the corners and angles of the forms.

- Vibration shall be applied only by experienced operators under close supervision, at the point of deposit and in the area of freshly deposited concrete. The vibrators shall be inserted and withdrawn out of the concrete slowly. The vibration shall be of sufficient duration and intensity to thoroughly compact the concrete, but shall not be continued so as to cause segregation. Vibration shall not be continued at any point to the extent that localized areas of grout are formed.

- Application of vibration shall be at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective.

- Vibration shall not be applied directly or through the reinforcement to sections or layers of concrete which have hardened to the degree that the concrete ceases to be plastic under vibrations. It shall not be used to make concrete flow in the forms over distances so great as to cause segregation, and vibrators shall not be used to transport concrete in the forms.
SPECIFICATIONS  
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- Vibrator shall be supplement by such spading as it necessary to ensure smooth surface and dense concrete along form surfaces and in corners and locations impossible to reach with the vibrators.

- The use of implements such as compressors which are likely to disturb or disarrange reinforcement or formwork shall not be permitted.

Concrete shall be placed in horizontal layers not more than 300mm thick as hereinafter provided. When less than a complete layer is placed in one operation, it shall be terminated in a vertical bulkhead. Each layer shall be placed and compacted before the preceding batch has taken initial set to prevent injury to the green concrete and avoid surfaces of separation between the batches. Each layer shall be compacted so as to avoid the formation of a construction joint with preceding layer which has taken initial set.

When the placing of concrete is temporarily discontinued, the concrete after being coming firm enough to retain its form, shall be cleaned of laitance and other objectionable material to a sufficient depth to expose sound concrete. To avoid visible points as far as possible upon exposed faces, the top surface of the concrete adjacent to the forms shall be smoothed with a trowel.

Immediately following an approved discontinuance of placing concrete all accumulations of mortar splashed upon the reinforcement bars and the surfaces of forms shall be removed. Dried mortar chips and dust shall not be puddled into the unset concrete. If the accumulations are not removed prior to the concrete becoming set, care shall be exercised not to injure or break the concrete steel bond at and near the surface of the concrete while cleaning the reinforcement bars.

C 10

PRECAST HOLLOW CONCRETE BLOCKS [HOURDIS] FOR RIBBED SLABS:

C 10.01

Material and Manufacture

Aggregate shall be so sized, graded, proportioned and thoroughly mixed in a batch with such proportions of cement and clean water as to produce a homogeneous concrete mixture. However, in no case shall the proportion of cement in the mixture be less than five (5) standard [each weighing 50 Kgs] per cubic meter of concrete.

Precast hollow concrete blocks (hourdis) for a ribbed slab shall be manufactured in approved vibrated, machine. If for any reason the strength requirements is not achieved,
Cement shall be increased at the Contractor’s own expense. The blocks shall be cured for twelve (12) consecutive days and shall be at least twenty-one (21) days old before incorporation in the Works. The blocks shall be of an approved pattern of withstanding a compressive force applied at the ends of 30 kgs/cm² based on the gross sectional area of the block obtained without deducting voids.

The blocks shall be hard, sound, durable, sharp, clean with well defined arises, free from cracks and flaws or other defects and of the dimensions shown on the Structural Drawings. The blocks shall be obtained from an approved local factory.

C 10.02

Workmanship
Precast hollow concrete blocks (hourdis) shall be laid exactly in a line with the cells on the long dimensions. Close edge blocks shall be used at the end; the dimensions of the ribs and size of reinforcing bards shall be exactly according to the Structural Drawings. In narrow width specially made half blocks shall be used and full block shall not be used along their length (with the calls along the long dimensions of the rib.)

The blocks are to be laid on adequate forms. All blocks shall be cleaned and thoroughly wetted with clean water before the concrete is poured and labourers shall not be allowed to walk on them. Any block found to be defective or damaged during concreting operations shall be removed and replaced before pouring the concrete, all at the Contractor’s expense.

C 11

FORMWORK

General
The Contractor shall be responsible for the design and stability of the formwork. The Contractor shall submit a full program of work indicating the various phases for the erection and removal of forms and the manner in which he intends to execute all concrete works.

C 11.02

Material
All forms shall be of wrought lumber and shall be built mortar tight and of sufficient, rigidity to prevent distortion due to the pressure of the concrete and other loads incident to the construction operations. Forms shall be constructed and maintained so as to prevent warping and the opening of joints due to shrinkage of the lumber.
The forms shall be substantial and unyielding and shall be so designed that the finished concrete will conform to the proper dimensions and contours. The Contractor shall take into consideration the effect of vibration on the formwork, and shall be responsible for any damage or default resulting thereof.

C 11.03 Workmanship

Forms shall be inspected by the Engineer prior to installation of reinforcement.

The number of spacing of the form struts and braces shall be such that the forms will be braced rigidly and uniformly lock joints between form sections shall be free from play or movement.

The shape, strength rigidity, watertightness and surface smoothness of re-used forms shall be maintained at all times. Any warped or bulged lumber must be resized before being re-used. Forms which are unsatisfactory in any respect shall not be re-used.

Metal ties or anchorages within the forms shall be so constructed as to permit their removal to a depth of at least 40mm from the face within injury to the concrete. In case ordinary wire ties are permitted, all wires, upon removal of the forms, shall be cut back at least 10mm. From the face of the concrete with chisels or nippers for green concrete, nippers are necessary. All fittings for metal ties shall be of such design that the cavities produced upon their removal are the smallest possible. The cavities shall be filled with cement mortar and the surface left sound, smooth, even and uniform in colour.

All forms shall be treated with oil and saturated with water immediately before placing the concrete. For members with exposed faces, the forms shall be treated with approval oil to prevent the adherence of concrete.

Any material which will adhere to or discolour the concrete shall not be used.

The Contractor shall provide means for accurately measuring the settlement of the forms during placement of the concrete and shall make all necessary corrections as directed by the Engineer.
C 11.04 Removal of Form-work

In the determining of the time for removal of forms, consideration shall be given to the location and character of the structure, the weather and other conditions influencing the setting of the concrete and the materials used in the mix. In general, the forms of any positions of the structure shall not be removed until the concrete is strong enough to prevent injury to the concrete.

When the forms are removed. Unless otherwise directed by the Engineer forms shall remain in place for the following specified period of time:

- Centering under beams : 21 days
- Floor slabs : 21 days
- Walls, sides of beams and other vertically formed surfaces : 3 days

Method of form removal likely to cause overstressing of the concrete shall not be used. In general, the forms shall be removed from the bottom upwards. Forms and their supports shall not be removed without the written approval of the Engineer. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight. Centers shall be gradually and uniformly lowered in such a manner as to avoid injurious stresses in any part of the structure.

The Contractor shall include in his prices for any formwork which may have to be left in position due to the impossibility of removal of same.

C 12 REINFORCEMENT

C 12.01 General

The Contractor shall prepare for his own use bar bending Schedules from the information given on the Drawings and in these Specifications. These Schedules shall be submitted to the Engineer for approval which shall in no way release the Contractor of his responsibility for the correctness of these Schedules.

All reinforcement shall be placed strictly in accordance with the Drawings and as instructed in writing by the Engineer. Nothing shall be allowed to interfere with the required disposition of the reinforcement, and the Contractor shall ensure that all parts of reinforcement are placed correctly in position and are temporarily fixed where necessary to prevent displacement before or during the process of tamping and ramming the concrete in place. The ties, links or stirrups connecting the bars shall be taut so that the bars are properly braced the inside of their curved part small be in actual contact with the bars, around which they are intended to fit.
Placed correctly in position and are temporarily fixed where necessary to prevent displacement before or during the process of tamping and ramming the concrete in place. The ties, links or stirrups connecting the bars shall be taut so that the bars are properly braced the inside of their curved part small be in actual contact with the bars, around which they are intended to fit.

C 12.02 Type and Quality of Steel Reinforcement

A - Hot-Rolled Steel Plain Rods and Bars

Hot rolled steel plain rods and bars shall conform to the strength requirements and minimum elongation of the Standard Specification for Deformed Billet-Steel Bars of Grade 40 with minimum yield strength 2400Kg/cms (35000 psi) for concrete Reinforcement of ASTM Designation (A-615) or equivalent.

B - Deformed Steel Rod and Bars

Deformed steel and bars shall conform to the requirements of the Standard Specification for Deformed Billet-Steel Bars of grade 60 with minimum yield strength 4200 kg/cm² (60000 psi) for concrete reinforcement of ASTM Designation (A-615) or equivalent.

C 12.03 Wire

Wire for bending reinforcement bars shall be of soft black annealed mild steel wire. The diameter of the Wire shall not be less that 16 S.W.G. (1.6mm) and the binding shall be twisted tight with proper pliers. The free ends of the binding wire shall be bent inwards.

C 12.04 Order Lists

Before ordering material, all order lists and bending diagrams detailed in accordance with the latest revision of AGI Building Code shall be furnished by the Contractor for the approval of the Engineer, and no material shall be ordered until such lists and steel bending diagrams have been approved. The approval of order lists and bending diagrams by the Engineer shall in no way relieve the Contractor of his responsibility for the correctness of such lists and diagrams. Any expenses incurred to the revision of material furnished in accordance with such lists and diagrams to make and comply with the design drawings including cut and waste shall be borne by the Contractor.
C 12.05 Protection of Material

Steel reinforcement shall be protected at all times from injury. When placed in the work, it shall be free from dirt, detrimental scale, paint, oil, loose, rust, grease or other foreign substances.

C 12.06 Fabrication

Bar reinforcement shall be bent to the shapes shown on the Drawings and Steel Bending (Diagrams), Bending dimensions and scheduling of bars for the reinforcement of concrete. All bars shall be bent cold, unless otherwise permitted by the Engineer. No bars partially embedded in concrete shall be bent except as shown on the plans or specifically permitted by the Engineer.

C 12.07 Placing and Fastening

All steel reinforcement shall be accurately placed in the position shown on the Drawings and firmly held during the placing and setting of concrete. Bars shall be tied at all intersections except where spacing 300mm in each direction, in which case alternate intersections shall be tied.

Distance from the forms shall be maintained by means of stays, blocks ties, hangers, or other approved supports. Blocks for holding reinforcement from contract with the forms shall be precast mortar blocks of approved shapes and dimensions or approved metal chairs. Metal chairs which are in contact with the exterior surface of the concrete shall be galvanized. Layers of bars shall be separated by precast mortar blocks or by other equally suitable devices. The use of pebbles, pieces of broken stone or brick, metal pipe and wooden blocks shall not be permitted. Reinforcement in any member shall be placed and then inspected and approved by the Engineer before the placing of concrete begins. Concrete placed in violation of this provision may be rejected and its removal is required.

C 12.08 Splicing

All reinforcement shall be furnished in the full lengths indicated on the Drawings. Splicing bars, except where shown on the drawing, will not be permitted without the written approval of the Engineer, Splices shall be staggered as far as possible.

Additional splices, other than those shown on the Drawings; and allowed by the Engineer, shall be at the Contractor’s own expense.

The cost of all supports for holding reinforcement bars shall be borne by the Contractor.
C 13 CURING AND PROTECTION

C 13.01 Water Curing

All concrete shall be cured for a period of time required to obtain the full-specified strength but not less than seven (7) consecutive days. Unformed surfaces shall be covered with sand burlap, or other approved fabric mats kept continually wet. If the forms are removed before the end of the curing period, curing shall be continued as on the uniformed surfaces. When burlap, sand or other approved fabric materials are used, they shall not cause any undesirable finish such as rough surface and discolouring where exposed to light. Unhardened concrete shall be protected from heavy rains or flowing mechanical injury and the Contractor shall submit for the Engineer’s approval his construction procedure which is designed to avoid such an eventually. No fire or excessive heat shall be permitted near or in direct contact with concrete at any time. Water for curing shall conform to Section 3.6.

C 13.02 Curing with Curing Media

Curing medium shall meet all requirements of the specifications for Liquid Membrane-Forming Compounds for Curing Concrete of ASTM Designation: C-309 and test for water retention by concrete curing materials of ASTM Designation: C-156.

The compound shall be applied to the concrete surface by means of a sprayer, roller or lamb’s wool applicator and shall be sprayed on. Ample time be allowed for the concrete surface to harden and to prevent any damage. The compound shall give a drying time not to exceed thirty minutes, and shall be applied undiluted directly from the manufacturer’s labelled container in accordance with the manufacturer’s directions and to the satisfaction of the Engineer.

The compound shall be completely compatible with adhesives, joint sealants and cement grout.

C 13.03 Payment

No separate payment shall be made for curing with water or with curing media. The cost of such curing shall be deemed to be included in the Unit Prices of “CONCRETE WORK”.

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C 14  CONCRETE [FAIR FACE] EXPOSED SURFACES

C 14.01 Formwork

Formwork for exposed concrete surface shall conform to
the applicable requirements of Section C 14, in addition
to those Specifications.

All concrete surfaces that are to be left exposed to view
as a finished surface except for precast concrete units,
shall be produced by vertical metal shuttering.

The quantity of the surface of concrete exposed to view
shall be consistent throughout the Project and the
following methods shall be adopted to obtain the required
finish.

- Metal forms of an approved type for precast
units

The Contractor may submit alternative proposals for the
Engineer’s approval if he so desires.

The Contractor is to submit to the Engineer for his
approval shuttering details and sequence of operation
relating to fair face concrete work. Sample panels shall
be constructed for all their face concrete finishes and
following the Engineer’s approval the panels will remain
on site and constitute a standard which must be
maintained throughout the duration of the Contract.

C 14.02 Coating Forms with Mineral Oil

In addition to the above forms or linings, the forms
shall be coated before placing reinforcement with an
approved colourless mineral oil free of kerosene.

All surplus oil on form surfaces and any oil on
reinforcing steel shall be removed.

C 14.03 Samples and Workmanship

The Contractor shall submit for approval a sample panel
not less than 600x1200mm to demonstrate the quantity of
the exposed concrete produced by forms at his own
expense.

The quantity of the finished work shall be measured
against the quality of the approved sample panel and the
work of inferior quality shall be repaired or replaced as
directed by the Engineer without any additional cost.
The quality of the finished surfaces shall be uniform in colour and consistency, whether in colour or in texture, in any of the finished surfaces, the Engineer may order the repair or the demolition of the portion of concrete work and the reconstruction of same at the expense of the Contractor and the Contractor shall have no right to claim for any expenses or time delay incurred.

Alternatively the Engineer may order the Contractor to plaster all exposed surfaces and bush-hammer the entire area of, concrete in the Project so as to render all exposed surfaces of concrete consistent throughout the Project at the Contractor’s own expense.

All concrete surfaces which are not in acceptance condition and which are required to be surface-finished as designated herein, shall be rubbed to a smooth and uniform texture with a carborundum brick and clear water as soon as the forms are removed and the concrete is ready to hone. The loose material formed on the surface shall be removed as soon as it dries by rubbing the surface with burlap or other approval material. A cement wash shall not be used.

Concrete surface shall be free from honeycombing, air holes, fins and projections arising from defective mixings, placing or formwork. When the formwork has been stuck off, the surface of concrete shall be left untouched until inspected by the Engineer. Any defective concrete work shall at the discretion of the Engineer be demolished completely and rebuilt or cut out and made good with concrete of the same proportions as the original. Such rectifications shall be to the satisfaction of the Engineer and at the Contractor’s own expense.
## INDEX

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**BLOCK WORK**

D 1  **SCOPE**

These Specifications cover the supply if materials, manufacturer and workmanship of concrete blocks intended to be used for the construction of blockwalling, partitions, facings, claustras, etc., required for the Project in accordance with the Drawings, Bills of Quantities and as directed in writing by the Engineer.

D 2  **MATERIALS**

D 2.01  **Cement**

Cement for solid or hollow blocks and mortar shall be ordinary Portland Cement ASTM Designation C 150-74 and white cement ASTM: c 91-71.

D 2.02  **Aggregates**

Aggregate or solid and hollow concrete blocks and mortar shall conform to the requirements for the aggregates in the "CONCRETE WORK" Section.

D 2.03  **Water**

Water to be used in blockwork shall conform to the requirements specified for water in the "CONCRETE WORK" Section.

D 2.04  **Lime**

Lime shall be non-hydraulic lime complying in all respects with B.S. 8980, and shall be prepared in accordance with the appropriate requirements of British Standard Code of Practice 121: Part 1: 1973, latest revision.

The Contractor must satisfy himself by analysis or otherwise that the ground lime is not adulterated or air-slaked.

Factory produced, dry hydrated, non-hydraulic or semi-hydraulic lime, ready for use, shall be mixed with sand and made into coarse mix or be soaked to putty by mixing with water and allowing to stand not less than (16) sixteen hours before use.

The lump or ground non-hydraulic or quicklime shall be slaked, run to putty and matured for not less than two (2) weeks.
MANUFACTURE OF CONCRETE BLOCKS

Aggregate shall be so sized, graded, proportioned and thoroughly mixed in a batch mixer with such proportions of cement and water as to produce homogeneous concrete mixture. However, in no case shall the proportion of cement in the mixture be less than five (5) standard bags (each weighing 50 kgs) per cubic meter of concrete.

Precast concrete blocks shall be manufactured in approved vibrated machines. If for any reason the strength requirements is not achieved, the cement shall be increased at the Contractor’s own expense. The water used in the mix shall be clean and of a sufficient quantity to allow complete hydration of the cement without providing an excess when moulding.

Concrete blocks shall be hard, sound, durable, sharp, rect- angular shape, clean with well define arises free from racks and flaws or other defects.

Concrete blocks shall be either obtained from an approved local factory or manufactured on the Site. If manufactured on Site, the blocks shall be pressmoulded in approved moulds and vibrating presswire machines with a minimum of 2800 cycles per minute.

Blocks manufactured on the Site shall be cured in the shade by being kept thoroughly moist with water applied by sprinklers or other approved means for a period of at least seven (7) days. The blocks shall be stocked on a clean and level platform free from earth or other impurities during the curing process, and shall be stocked in honeycomb fashion after curing. The blocks shall not be used prior to one (1) month after the date of manufacture, not shall any block be used that have not been inspected and approved by the Engineer.

Concrete blocks (solid or hollow) shall be of the following dimensions:

- Height = 200 mm + 1 % Tolerance
- Length = 400 mm + 1 % do.
- Width = As required + do.

The nominal width of blocks shall be as indicated on the Drawings and as directed in writing by the Engineer.

Hollow concrete blocks shall comply with the following requirements:

Compressive strength at Twenty-Eight (28) Days over Cross- Sectional Area: -

a) Load-Bearing Walls
   - 60 kgs/cm² average of 12 blocks
   - 50 kgs/cm² minimum for any block

3-60
b) Non-Load-Bearing Walls

30 kgs/cm² average if 12 blocks
25 kgs/cm² minimum for any block

Water Absorption
20 % or less of dry weight

The design of the cavities and webs of the hollow concrete blocks shall be submitted to the Engineer prior to manufacture. The thickness of the face shell and of the membrane of solid portions shall be nowhere less than forty (40). The combined thickness of the solid portions shall be not less than one fourth (1/4) of the width and length of the block respectively.

MORTAR

Mortar shall be prepared in the following proportions with the addition of the minimum quantity of clean water for workability.

Cement and sand mortar (1:3) shall be composed of one part cement to three parts of sand by volume.

Hydrated lime up to 1/4 (one quarter) by volume of the dry cement may be added for bedding blocks, upon the approval of the Engineer, to improve workability without appreciably reducing the strength.

The ingredients for cement and sand shall be measured in proper clean gauge boxes and the mixing shall be carried out by means of an approved mechanical batch mixer.

In the cast of cement-lime mortar, the sand and lime shall be mixed first and the cement added. It shall be assumed that the lime has not increased the bulk of the sand.

Cement mortars shall be used within thirty

WORKMANSHIP

All blockwork shall be set out built to the respective dimensions, thickness and heights shown on the Drawings and/or instructed in writing by the Engineer.

All walls and partitions, where shown on the Drawings without indicating the type of the block to be used, shall be built in hollow concrete blocks, unless otherwise directed in writing by the Engineer.
The blocks shall be well soaked before being used and the tops of walls left off shall be wetted before work is recommenced. All blocks shall be well buttered with mortar before being laid and all joints shall be in uniform manner and shall not exceed 10mm, no one portion being raised more than 1.00m above another at one time, and wall of partition necessarily left at different levels, must be racked back. All perpends, quoins, internal and external angles, etc. properly bonded together and levelled round. All blockwork shall be plumbed vertically.

The surface of the walls and partitions prepared for plastering, shall have the joints raked out 20mm from the face of the wall to form key for the plaster.

All blockwalls shall be bonded to reinforced concrete columns by means of wall ties, complying in all respects with B.S. 1243 latest edition. The ties shall be minimum 200mm long of which 100mm shall be embedded in the re-d concrete column and the remainder set into the block wall at the rate of two (2) ties per meter. Partitions shall be bonded to main wall by toothing at every fourth course into main wall to a depth of not less than 100mm.inforce

All walls and partitions shall be properly cured by sprinkling water for a period not less than three (3) days after completion of laying the course.

Walls and partitions terminating against soffits of beams or slabs shall be lightly wedged with metal wedges after mortar in bed joints has attained its initial set, and the joint packed with mortar.

Cut and fit blockwork next to reinforced concrete door, window, jambs and sills, and form chases for the ends of the door and window lintels. No hollow blocks shall abut any built-in fixtures e.g. door and window frames, apertures, louvers, etc. .

The cavity between skins of blockwork shall be 100mm (nominal) wide and kept clear of mortar dropping throughout the construction of the hollow walls. The skins of hollow walls are to be tied together with butterfly twist type galvanized steel wire to the approval of the Engineer and built into each skin one meter apart horizontally and every alternate course, staggered.
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SECTION E

STONEWORK

E 1  Scope

These Specifications cover stonework building intended to be used form external walls, required for the Works in accordance with the Drawings, Bills of Quantities and as directed in writing by the Engineer.

It also covers the copings covering the parapet of the roof.

E 2  Materials

Stone building to walls shall be durable, local stone, Mizzi yahoudi or mizzi Hilou of a quality suitable to ensure permanence in the structure. It shall be (Toubzeh) dressed, free from cracks, seams, holes, shakes, objectional irregularities of colour, impurities, structural weaknesses and other defects that would tend to increase unduly the deteriorations from natural causes.

All stones shall be selected well in advance of the time required. Samples of stone materials and dressing shall be submitted for the Engineer’s approval 30 days before delivery of any such material to Site.

Mortar for all masonry shall consist:

1 part cement

6 parts of fine aggregates

All copings for covering the parapet shall be durable, local stone as mentioned above. The height and width of copings will be as specified on the Drawings.
Workmanship

Walls shall be carried up in a uniform manner no one portion being allowed to rise more than four courses above one another at one time. The total thickness of stone building and concrete backing shall be 30cm as shown on Drawings.

All stone shall be hand placed. Courses shall be solidly bedded with full mortar beds and joints fully squeezed out. All stones shall be cleaned and thoroughly wetted before setting.

To ensure even and regular width of beds and joints when setting stones, the Contractor shall use hardwood wedges to ensure close and regular fitting between beds and joints.

All stones shall be solidly bedded and jointed in mortar. Copings shall be fixed on the top of the parapet by mortar.

At completion of masonry walls, joints shall be cleaned wetted and pointed with mortar composed of: part white cement and two parts of very fine crushed stone sand tinted to the colour selected.

The Contractor, when executing, shall ensure that the mortar is pressed tight into the joints by means of approved tools for pointing.

Care shall be exercised to avoid spreading in the faces of the stones.

The Contractor shall set up samples for the Engineer’s approval before executing any pointing.
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SECTION F

ROOFING, WATERPROOFING AND THERMAL INSULATION

F 1 SCOPE

These specifications cover, waterproofing, roofing and thermal insulation, to be used for underground structures floors and roof decks required for the Works in accordance with the Drawings, Bills of Quantities and as directed in writing by the Engineer.

F 2 MATERIALS

F 2.01 Dampproofing

All substructures, floors of ground floor of kitchens + bathrooms have to be painted with a liquid waterproofing.

F 2.02 Waterproofing of exterior walls

This will be added to the exterior plastering of walls. An integral concrete waterproofing compound that will reduce moisture absorption in the plastering mixture

F 2.03 Waterproofing of the roof

A sloping screed consisting of lightweight concrete screed shall conform to B.S.3797: lightweight aggregate for concrete. The lightweight aggregate shall be such a Vermiculite, Alveolite, etc… aggregate of an exfoliated micaceous mineral aggregate incombustible and chemically inert, obtained from an approved manufacturer, graded and mixed in accordance with the manufacturer’s instructions.

The lightweight aggregate shall be delivered to the Site in the manufacturer’s sealed and branded containers which shall be clearly marked to show the grade of lightweight aggregate contained therein. They shall be stored in a covered shed with floor raised off the ground and bags stacked not more than 3.00 meters high.

Mixing Proportions

The lightweight concrete screeds shall be measured, mixed applied and cured in accordance with the manufacturer’s in-structions and to the satisfaction of the Engineer.

Gauges boxes shall be used for the measurement of light-weight aggregate and the following mixing table shall be strictly observed.
SPECIFICATIONS
ROOFING AND WATERPROOFING

| Nominal Mix | Lightweight Aggregate | Meter Cube | Cement Contents | Water 8 : 1 1.00 150 Kgs. 44 gallons [200 Litres] |

F 2.04  **Waterproofing**

An application of a bituminous waterproofing consisting of an unknown polyester reinforcement (250 grm/m² minimum) incorporated in thermofusible elastomeric bitumen.

F 2.05  **Workmanship**

Prior to the beginning of the roofing works, the Engineer and the roofing superintendent shall proceed to the inspection and approval of the receiving surfaces, the upstands at roof edges, the drains, vent pipes and other venting devices, the construction joints etc.

The general contractor will be notified in written of all defects of the flat surfaces or details and work shall not proceed until such defects have been corrected.

One coat of primer is painted over all the surface.

Installation of the bituminous layers shall be carried out in conformity with the manufacturer’s specifications and using propane torch welding only.

Asphalt coatings shall be softened but not melted as to avoid superheating using a single-nozzle torch of adequate size. Rolls shall overlap 75mm on sides and 150mm at ends. All inadequately welded seams will be refused. All superheated areas or parts will be refused and will require adequate repair in accordance with the degree of deterioration of the membrane.

Air blisters, wrinkles impact and tearing marks and protective granules pounding marks are not admissible. Should these defects occur roofing works shall be carried out again.
F 2.06  Bituminous Flashings

A plain underlay bonded to the support with previously applied primer coating or welded to it with propane torch. This underlay shall be unrolled parallel to the upstanding element in one meter width extending 150mm onto the current surface underlay.

Apply the current surface-finishing layer onto the flashing underlay and then recover with the flashing-finishing layer extending 200mm onto the current finished surface.

This layer shall be welded with propane torch in full adherence that no air is entrapped between layers. Side and end laps shall be staggered over underlay seams and 75mm wide.
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SECTION G

JOINERY AND IRONMONGERY

G 1  GENERALLY

Joiner’s work shall be carried out in accordance with the drawings and the principles of first joinery construction. Unless specifically stated otherwise sizes on drawings are finished sizes.

G 2  TIMBER GENERALLY

Timber shall comply in all respects with B.S. 881/589 for Nomenclature of Commercial Timbers including Sources of Supply, and B.S. 1186 quality of timber and workmanship in joinery, latest editions.

Timber shall be of an approved variety and quality suitable for the purpose for which it is to be used and equal to samples approved by the Engineer.

All timber shall be properly seasoned and shall be planed square, straight and true and shall be free from the following defects.

- Sapwood slits, ring shakes and soft pith.
- Checks exceeding 1.5mm wide.
- Checks exceeding 1.5mm wide.
- Checks more than half the thickness of the timber in depth.
- Knots exceeding 20mm mean diameter.
- Knots exceeding half the width of the surface.
- Decayed or dead knots unless cut out and plugged.
- Loose knots or knot unless cut out and plugged.
- Pitch pockets.
- Decay and insect attack including pinworm holes.

Timber shall be pressure impregnated by a method to be approved by the Engineer. The timber is to be of the correct moisture content specified in B.S. 1886 Part 1 and shall be free from surface moisture and dirt. Treatment is to be carried out after all cutting and shaping is completed and care is to be taken to avoid damage to surfaces of treated timber in subsequent handling. If treated timber is unavoidably cut or damaged a liberal application of preservative is to be made to damaged surfaces.

Samples of every type which the Contractor proposes to use in the Works shall be sent to the Engineer for his approval. Each sample shall be labelled and the label shall state the species of the timber and the purpose for which it is to be used. Timber used in the Works shall be equal in strength characteristics and appearance to the approved samples.
In jointed panels each piece shall be of the same species. Joinery for staining or polishing has all surfaces of the same species and same character of grain running in the same direction.

All plugs inserted after cutting out defects shall be the full depth of the hole and the grain of the plug shall run in the same direction as the grain of the piece.

Timber connectors where used shall be two single-sided toothed plates (round or square) for demountable joints or one double sided toothed plate (round or square) for permanent joints to conform with B.S. 1579, latest addition.

Timber shown to be plugged to wall shall be properly and securely fixed by means of raw-plastic or hardwood plugs cut on the twist.

Nails shall be in accordance with B.S. 1202 Steel nails and screws shall conform to B.S. 1210 Wood Screws, of latest edition.

Timber to be used for each position of the Works shall be as indicated on the drawings and as stated in the Bill of quantities. In general joinery exposed work shall be executed in first grade hardwood as hereinafter specified.

All grounds and other timber to be built into concrete or blockwalls or otherwise covered shall first be coated all over with approved wood preservative, suitable for the position in which the member is to be incorporated.

**SOFTWOOD**

Softwood shall be Douglas fir, longleaf pine, European redwood or other approved softwood unless otherwise shown on the drawings.

Blocking timbers or the like shall be Russian whitewood “Shuh” or other equal and approved.

Where pine is required it shall be Parara Pine from South America of the sizes indicated on the drawings.

**HARDWOOD**

Hardwood shall be Teak, Canadian clear, Canadian Yellow Birch, Merranti, “Zeine” first grade dense timber or other equal and approved.
Where mahogany is required it shall be first quality Honduran mahogany of sizes indicated on the drawings.

Where beech is required it shall be first quality European of the sizes indicated on the drawings.

**PLYWOOD**

Plywood shall consist of an old number of plies arranged so that the grain of each layer is at right angles to the grain of the adjacent layer or layers. The plies shall be not pressed during adhesion and shall have a finished thickness as shown on drawings, or shall have refinished plywood 7mm thick such as obtained from Vitrus Werke and Simpson or equivalent.

In the case of plywood having 3 plies the core shall be not more than 60 percent of the total thickness.

In plywood having more than 3 plies the faces and all plies with the grain running in the same direction as the faces shall have a combined thickness of between 40 percent and 65 percent of the total thickness of the ply.

The plywood shall be free from end joints (including scarf-joints in veneers), overlaps in core veneers, dead knots, patches and plugs, open defects, depressions due to defects in core, insect attack (except isolated pinworm holes through face veneers only), fungal attack and from discolouration differing from that normally associated with species.

All plywood shall be of Exterior Grade and shall conform to the applicable requirements of" B.S. 1455 "Ply-wood manufactured from tropical hardwoods “ and B.S. 3493” information about plywood”.

**BLOCKBOARDS OR LATTE AND LAMINBOARD**

Blockboards and laminboard shall be of an approved manufacturer and guaranteed not to warp or change in size or suffer any kind of deformation. It shall be of timber specified and glued with anti-insect synthetic resin waterproof glue all through. All strengthening boards shall be fixed during manufacture.

Blockboard and laminated shall conform to the requirements of B.S. 3444 " Blockboard and Laminboard" and B.S. 3583” Information about Blockboard and Laminboard".

3-70
**G 7 VENEERS**

Timber for face veneer shall generally be first grade hardwood as indicated on the Drawings and/or in the Schedule of Doors obtained from an approved supplier.

The face veneers shall be hard, durable, and capable of being finished easily to a smooth surface, they shall be free from knots, worm and beetle holes, splits, dote, glue stains, filling and inlay of any kind or other defects.

The face veneers shall be applied to one or both sides of wood panels as shown on the Drawings.

Adhesives shall comply with the requirements of B.S. 1203 synthetic resin adhesives for plywood (Phenolic and amino- plastic) and shall ensure proper adhesion between plies.

**G 8 PLASTIC LAMINATE**

The plastic laminate facings conforming to B.S. 2572 Phenolic laminated sheet minimum 1.5mm shall be similar to Formica, Panelyte, Perstrop or other approved equal obtained from an approved manufacturer.

Colour and pattern shall conform to the sample approved by the Engineer.

Plastic laminate sheets shall be applied with a waterproof heat resistant adhesive of a type recommended by the plastic laminate manufacturer.

**G 9 MANUFACTURE AND WORKMANSHIP**

**G 9.01 General**

All Carpenter and Joiner Work shall be accurately set out, framed and executed in accordance with the detailed Drawings.

Joinery work shall be constructed to detailed drawings. Joints shall be made so as to comply with B.S. 1186 Part 2.

Joinery shall be cut and framed at an early stage, but shall not be glued or wedged until building is ready to receive it.
Framed work shall be properly morticed and renoned, wedged, glued and cramped together and dowelled where necessary. All external joinery work shall be put together with waterproofing glue.

The use of nails for fixing any items of joinery will not be permitted. Springs may be used for glazing beads only.

All screws shall be countersunk and puttied and all springs shall be punched and puttied.

All joinery such as architraves, beads etc., required to fit against the contour of irregular surfaces shall be accurately scribed to ensure a close connection.

All joinery which is to be polished, varnished or painted shall be finished smooth and clean by rubbing down with fine glasspaper.

G 9.02 Doors

Doors shall be to sizes shown on the Drawings. Doors hung folding shall have meeting beads screwed on. Glazing bars if required shall be of twice rebated section.

Flush doors shall be core framed up in softwood and covered with 6mm thick ordinary plywood or as shown on the Drawings.

The horizontal framing members shall have ventilation holes drilled in the vertical direction to avoid damage due to expansion of trapped air.

Hardwood edging shall be securely joined and dowelled to the framing all round the exposed edges and shall be splayed or rebated to take the edge of the plywood facing. Lock rails of fixing blocks shall be built into the framing and their positions marked on the facing.

Glazing beads shall be of hardwood (beech or the like) moulded and screwed as detailed on the Drawings.

Doors and joinery items etc. shall be carefully and accurately fitted to give a uniform clearance of not more than 3mm all round.

G 9.03 Fittings Generally

Shelves, divisions, counter tops, panels, drawers and the like shall be of the dimensions and sizes shown on the drawings and shall be screwed to bearers, framing or brackets.
Blockboards in shelves, divisions, counter tops, panels, drawings and the like shall have hardwood lipped to all edges.

Prefabricated fittings and fixtures such as floor and wall cabinets, cupboards, counters and the like shall be of the size, type and dimensions shown on the drawings and shall be fabricated of the materials shown on the drawings and described in the Specification. The fittings, etc. shall be accurately constructed. The doors, drawers, etc. shall all fit and open and close smoothly.

Before starting repetitive fabrication of any component, prototypes shall be prepared and approved.

All components shall be made to B.S. 1186: Part.2.

Prefabricated fittings and fixtures shall be fixed in the positions indicated on the drawings after all floor, wall and ceiling surfaces have been formed or constructed. All work next to walls, floors and ceilings shall be soundly fixed and scribed to fit snugly against same.

The Contractor shall construct such ground works as are necessary to provide a suitable base and fixing for the prefabricated joinery works.

All blockboards in prefabricated fittings and fixtures shall have hardwood lipping to all edges.

Prefabricated fittings and fixtures shall be complete with hardware as shown on the drawings or as approved by the Engineer.

G 9.04 Veneering and Finishes

Veneering and finishes to doors, etc. shall be in accordance with the Drawings and as directed in writing by the Engineer.

The decorative veneer shall be laid at right angles to the grain of the face whether based on plywood or blockboards. Undulations shall be smoothed out by sanding or scraping and the moisture content of the panel and veneer matched to reduce differential shrinkage.

Laminated plastic sheets which are used as facing veneer on plywood or blockboard shall be applied with a waterproof, heat resistant adhesive of a type recommended by the manufacturer of laminated plastics.

Finishes with paint to faces of doors and cupboards shall be enamel oil paint as specified under Section “PAINTING AND DECORATING”.

3-73
G 10  
**INSPECTION**  
Facilities shall be given to the Engineer for the inspection of all joinery works in progress in the shops and on the Site.

G 11  
**TRANSPORT AND PROTECTION**  
The joinery shall be kept well protected during transit and shall be handled and packed carefully to avoid its being damaged and shall be covered and kept clear of the ground where on the Site.

G 12  
**MAKING GOOD ALL DEFECTS**  
Should any shrinkage or warping occur or any other defects appear in the joinery work before the end of the defects liability period, all defective work shall be taken down and renewed to the entire satisfaction.

G 13  
**IRONMONGERY**  
Ironmongery shall be first quality to be obtained from an approved manufacturer as specified.

The Contractor shall submit a schedule of ironmongery for the approval of the Engineer before placing any supply order. The Engineer’s approval of such schedule shall not relieve the Contractor from furnishing all items of hardware required under the Contract.

G 14  
**MASTER-KEYING**  
The Contractor shall set up the locks for a system of master keying. Two change keys shall be furnished for each lockset.

G 15  
**PROTECTION AND DEFECTIVE WORK**  
All joinery work shall be protected from damage during the course of the work and when handed over shall be to the entire satisfaction of the Engineer. Before handling over, the Contractor shall ensure that all doors, fittings, etc. work easily and shall make all necessary adjustments including those needed during the maintenance period. Any joinery that splits, shrinks or warps from want of seasoning, unsoundness or bad workmanship shall be removed and replaced at the Contractor’s expense. Ironmongery shall be over hauled, cased and oiled before handing over and all paint, etc. Shall be removed and left in a clean and perfect working order.
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SECTION H

METAL WORK

H -1 SCOPE

These Specifications cover ferrous and non-ferrous works intended to be used in the Project all in accordance with the Drawings and as directed by the Engineer.

H -2 MATERIALS

H -2.01 Steel

Steel plates, and structural steel shaped sections shall conform to the requirements of B.S. 4 latest edition for structural sections, Part 1 Hot rolled sections and Part 2 Hot-rolled hollow sections (Metric Series).

H -2.02 Bolts and Nuts

Bolts and nuts shall conform to the requirements of B.S. 4190: I.S.O. metric black hexagon bolts, screws and nuts.

H -2.03 Washers

Plain washers shall be made of steel. Taper or other specially shaped washers shall be made of steel or malleable cast iron and shall conform to the requirements of B.S. 4230 Metal washers for general engineering purposes.

H -2.04 Galvanized Steel Pipes

Galvanized steel pipes shall conform to the requirements of B.S. 1387 - I.S.O. “Medium Series”.

H -2.05 Paint

Paint for Metalworker shall comply with the applicable requirements as specified under “PAINTING”.

H -2.06 Aluminium

All aluminium elements shall be manufactured of extruded sections of aluminium alloy, mechanically jointed. Fittings shall be aluminium alloy in accordance with B.S. 1331 the latest edition. All parts and members shall be of aluminium commercial quality like (Al - Mg - Si) heat treated, free from defects impairing its strength and durability and containing not more than 0.4% copper. All exposed surfaces shall be polished to a mirror-like surface, free from defects, and shall be light etched and anodized in a dark brown finish as shown on Drawings and as directed in writing by the Engineer.
Aluminium shall be treated to comply with B.S. 1615 and B.S. 2987 to provide an anodization not less than 25 microns thickness.

All aluminium sections shall present clear straight and sharply define lines and shall be free from defects and imperfections that may impair their strength.

All screws, bolts and other necessary accessories shall be of aluminium or other non-corrodable material and shall match in colour and consistency the finish of the anodized aluminium.

Aluminium elastic glazing beads shall be provided to all windows and doors which are assembled by pressure to fit with the relevant groove in the profile.

The glazing bars shall be treated or interlaced at points of intersections and machine tenonned to frame.

H 3

MANUFACTURE

H 3.01 General

The Contractor shall be responsible for the correctness and accuracy of the dimensions of the finished articles.

He shall therefore carefully check the dimensions indicated on the Drawings, verify any change ascertain the sizes at Site which will enable him to prepare Final working Drawings for fabrication and erection purposes. Such drawings shall be submitted to the Engineer for his verification and approval.

Fabrication Orders can only be placed after Contractor has obtained in writing the approval of the Engineer on the above Drawings.

The steel sections where specified to be factory rustproof shall be rustproofed by hot dip galvanized, metalizing or sheradizing process. The rustproofing shall be sufficient to withstand the 72 hours salt-spray test as provided for in B.S. 1391. If the rustproof coating shall be damaged during the progress of work, the damaged part shall be recoated to minimum the original thickness to the satisfaction of the Engineer.
H -3.02 **Flush Steel Door and Frame**

Flush steel door shall be fabricated of hot rolled steel sections for framed skeleton with diagonal bracings and lined both faces with sheet steel of thickness as shown on Drawings or stated in the Bills of Quantities, riveted to framed skeleton as shown on the Drawings. The Frame shall be made of hot-rolled steel sections and shall be provided with No. 8 anchors, one end welded to frame and other end dovetailed.

H -3.03 **Hollow Metal Door Frames**

Hollow metal door frames shall be purpose made to the profiles and sizes shown on the drawings and obtained from an approved manufacturer. The doorframes shall be from 1,5mm thick twice laminated steel.

The frames shall be stored in a clean, dry place, off the ground and protected from the weather.

The frames shall be free of all dents, bumps, slits, and cracks and any defective frames shall be made good or replaced at the Contractor’s own expense.

H -3.04 **Aluminium Windows, Doors**

The anodized aluminium windows and doors etc… with all necessary accessories and fittings shall be of the pattern, design, dimensions and thickness shown on the Drawings and obtained from an approved manufacturer.

Prints of shop Drawings for aluminium Windows, doors, frames, etc.. showing the dimensions, sizes, thickness, materials, finishes, joinings, attachments, fasteners and the relation of this section to adjoining work, shall be submitted to the Engineer for approval before ordering any material. All work shall be fabricated and erected in accordance with the approved Drawings.

All aluminium windows, doors, frames, etc… shall be factory assembled and reinforced according to the Drawings, complete with hinges, glazing gaskets and anchors. The only Site work allowed on aluminium units is fixing in position and glazing. The finished surfaces shall present a clear surface free from alloy defects, scratches, or other surface blemishes.
WORKMANSHIP

Steel Elements

All steel parts shall be accurately set out, cut, framed, assembled and executed using proper bolts or welding electrodes. All cut parts shall be sawn cut, no oxygen burning shall be permitted except for pipe supports. All welding shall be electrical welding, clean and of proper workmanship. All cut parts and welded sections shall be ground, even and filed smooth with rounded edges.

All steel members in contact with the soil shall be painted with two (2) coats of protective asphalt paint. All doors, frames, staircases, etc... shall be given at least one (1) coat of approved rust inhibiting primer before delivery to Site.

Frames for doors and windows shall be provided with not less than (3) adjustable type anchors on each jamb, maximum distance between anchors shall be eight hundred (800mm).

All joints shall be machined to a close fit and all pins and screws shall be countersunk and dressed flush after assembly.

Forging shall be sharp and true curbs and intersections, members of the same size shall be halved together.

The plain surfaces shall be smooth, free from warp or buckle. Moulded members and mitres shall be clean, cut, straight and ture. Construction joints shall be welded their full length and cleaned off flush on exposed surfaces.

All work shall be erected plumb and true to lines and rigidly secured to wall, floors or ceilings as shown on Drawings and to the satisfaction of the Engineer.

Hardware for steel doors, etc. shall be as specified under JOINERY & IRONMONGERY.

Aluminium Windows and Doors

The Contractor shall furnish and install all aluminium units as indicated on the Drawings. Workmanship and installation shall be in accordance with recommended standard of First Class Aluminium Manufacturers.

All aluminium work shall be performed in a shop where grade of metalwork is of recognized quality acceptance to the Engineer. All items shall be installed plumb, straight, square level and in proper elevation, plane location and
level and in proper elevation, plane and alignment with other work. All work shall be designed for adjustment to field variations, fitted with proper joints and intersections, adequately anchored in place, strictly in accordance with best practice.

Where aluminium surfaces come in contact with metals other than stainless steel, zinc, white bronze or small areas of other metals compatible with aluminium surfaces they shall be kept from direct contact with such parts by painting the dissimilar metal with a prime coat of zinc-chromate primer or other suitable primer, followed by one or two coats of aluminium metal-masonry paint or other suitable protective coating, excluding those containing lead pigments or a non-absorptive tape or gasket shall be placed between aluminium and dissimilar metals. Steel anchors and connecting members shall be hot dip galvanized or zinc plated after fabrication.

Aluminium surfaces in contact with lime mortar, concrete, plaster or other masonry materials, shall be painted with alkaline-resistant coatings such as heavy-bodied bituminous paint or waterwhite methacrylate lacquer.

Aluminium in contact with wood or absorptive materials which may become repeatedly wet shall be painted with two coats of aluminium metal-and-masonry paint or a coat of heavy-bodies bituminous paint. Alternately paint the wood or other absorptive material with two coats of aluminium house paint and seal joints with a good quality of caulking compound.

Where aluminium is in contact with treated, wood shall be treated with pentachlorophenol, 5% minimum concentration or approved equal, followed with the protective measures described for aluminium in contact with wood or other absorptive materials.

The aluminium work shall be designed and anchored to that the work will not be distorted nor the fasteners over-stressed from the expansion and contraction of the metal.

Before shipment from the factory, aluminium surfaces requiring protection shall be given a coating which will protect the metal during construction in areas where appearance of the finish on aluminium items is important, a coating of methacrylate type lacquer shall be applied as specified hereinafter.
Apply two sprayed coats of water-white methacrylate lacquer having a total minimum thickness of 0.015mm, which when applied to the aluminium surface shall be capable of withstanding the action of lime mortar for a period of at least one week in an atmosphere of 100% relative humidity at 40 °C, the action of 10% (by weight) muriatic acid for a period of six hours at 20 °C, and the action of atmospheric weathering for a period of 12 months. The coating shall be applied in the manufacturer’s plant to the exposed surfaces of all aluminium components subject to staining from alkaline mortar and plaster, abrasion and other construction abuses. Before application of lacquer, the manufacturers shall remove all fabrication compounds, moisture, dirt accumulations and other foreign materials to ensure proper lacquer adhesion.

Upon completion, the Contractor shall clean all aluminium work as required by removing protective tape or other coating, using mild soap or detergents and clear petroleum spirits.

Acids, caustics and abrasives not be used. Where cleaners are used to remove excess sealings compounds care shall be exercised to prevent damage to seals or staining or damage to adjacent work.

The Contractor shall be responsible for the protection of all aluminium work until the completion of the works, and only units in perfect working order and in perfect condition shall be accepted.

H -4.03 Hollow Metal Door Frames

Hollow metal door frames shall be fixed and shown on the drawings all in accordance with the manufacturer’s printed instructions and flushed up solid with plain concrete or cement mortar.

The rates for hollow metal door frames are to include for the supply and assembly of the complete unit including all necessary holes for hinges and lock, cutting off torsion threshold bar if necessary and fixing in walls in accordance with the manufacturer’s printed instructions and plain concrete or mortar filling as shown on the drawings.

H 5 BALUSTRADES AND RAILING

Balustrades and railings shall be of the materials and made to the sizes, dimensions and designs shown on the drawings.
E-1A Scope:

These Specifications cover the following systems that are intended to be used for the Project in accordance with the Drawings and as directed and approved by the Engineer:

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E-1B General requirements:

The Contractor shall supply all necessary labor and material, and shall install, complete ready for use, the above mentioned systems including the installation and wiring of miscellaneous equipment and devices, as indicated on the drawings and as herein specified.

The Contractor shall carry out the whole of the Electrical works in a workman like and substantial manner and in strict conformance with the codes, Standards and requirements listed in the following clauses, or approved equal.

All equipment and material supplied for this project shall be manufactured in strict compliance with the standards listed in the following clauses, or approved equal.

If actual ratings of equipment supplied under other sections are different than the values indicated on the Drawings, the Contractor shall implement all necessary modifications at no extra cost, to the approval of the Engineer and relevant Local Authorities.

E-1C Interference and Erroneous Locations:

The Contractor shall verify on Site all data and final locations of work done under other Sections of these Specifications, required for arranging the Electrical Works.

In case of interference with other works or erroneous locations with respect to equipment or structures, the Contractor shall supply all labour and materials necessary to complete the work in an approved manner.

E-1D Climatic Conditions:

Materials and equipment shall be suitable in all respects for operation on electrical systems under following climatic conditions:-
- Temperature
- 50 degree C. Max.
- Relative Humidity
- 100 percent Max.
E-1E Protection of Electrical Equipment:

Electrical equipment shall be protected against mechanical damage and from the weather especially from water dripping or splashing upon it, at all times during shipment, storage, and construction.

Equipment shall not be stored outdoors. Where equipment is installed or stored in moist areas, such as unheated buildings, open spaces, etc., it shall be provided with an acceptable means to prevent the moisture damage. This may be a uniformly distributed source of heat to prevent condensation.

Should any equipment or material be subjected to possible damage by water, it shall be dried out thoroughly and put through a special dielectric test as directed by Engineer, at the expense of the Contractor or shall be replaced by the Contractor without any additional charge.

Should any equipment or material be subjected to possible mechanical damage, the Contractor shall repair or replace the damaged equipment as instructed by the Engineer.

E-1F Codes and Standards:

The Contractor shall carry out all electrical works in accordance with the latest issue of the "Regulations for the Electrical Installations published by the Institution of Electrical Engineers (IEE) referred to as IEE Wiring Regulations hereinafter, and where not in contradiction with the latest requirements of Local Electrical Authorities and Civil Defense Administration.

If any redesign or modification of the Works is necessitated by the adoption of another approved code or due to Local Electrical Authorities or safety instruction requirements, the extra cost incurred (if any) both for redesign and material shall be borne by the Contractor.

All equipment and materials supplied for this contract shall be manufactured in strict compliance with the latest relevant recommendations of the IEC, if available. Otherwise they shall comply with the latest relevant Euro norm specifications unless otherwise specified or approved.

E-1G Acceptance Tests:

Any work which is not in accordance with the Specifications or to the satisfaction of the Engineer and / or local power authorities shall be removed and repaired at the Contractor’s expense. All material must be factory finished and/or painted to the approval of the Engineer.

E-1H Electrical Service:

The electrical power system will operate on 220 Volt/380 Volt, 3-phase, 4-wire, 50 Hz system.

The low current systems shall operate on the voltages specified or as recommended by the respective system manufacturer, to the approval of the Engineer.

E-1I Local Electrical Authorities' Requirements:

The Contractor shall attend to and afford all facilities to the Local Electrical Authorities and shall provide all drainage pits, terminal cable pits, terminal boxes for cables, underground ducts, etc. to facilitate all main feeder work. The Contractor shall be responsible for foreseeing any requirement as requested by the above mentioned authorities, and shall follow the Engineer's instructions on Site.

The Contractor shall be responsible for preparing any workshop drawings concerning transformer rooms, electrical (meter) rooms, feed-in routings, and shall consult the electrical authorities in accordance with the Engineer's instructions, to seek the approval of these authorities. The Contractor shall also be responsible for follow up of the application for electrical connection. The application form shall be filled in by the Contractor who shall follow up with the concerned authorities for final electrical connection to the project.
E-1J Abbreviations:

The following abbreviations shall have the significance set forth opposite each:

NEC : National Electrical Code (Standard 70) (USA).
BS : British Standards.
IEE : Institution of Electrical Engineers (UK).
EN : Euronorm (European Harmonized Standards).
UL : Underwriters Laboratories.
VDE : Verband Deutchcher Elektrotechniker.
IEEE : The Institute of Electrical & Electronic Engineers (USA).
NEMA : National Electrical Manufacturers' Association (USA).
ANSI : American National Standards Institute (USA).
DIN : German Industrial Standards.

E-1K Engineer's Drawings:

The Engineer's Drawings issued with these Specifications are complementary to these Specifications. These Drawings indicate the approximate location of all electrical devices and equipment. The exact and final location shall be subject to the prior approval of the Engineer on Site.

The Contractor shall check Architectural, Structural, Air-Conditioning, Plumbing and any other available Drawings to avert any possible installation conflicts. Should drastic changes from original plans be necessary to resolve such conflicts, the Contractor shall secure the Engineer's approval on necessary adjustments before any installation work is started.

All accessories and appurtenances that the Engineer deems functionally necessary for a complete installation shall be supplied and installed by the contractor whether or not explicitly indicated or described, at no extra charge.

Discrepancies shown on different Drawings or between Drawings and actual Site conditions, or between Drawings and Specifications shall be brought to the attention of the Engineer for a decision.

E-1L Shop Drawings, Samples and Other Submittals:

The Contractor shall submit shop drawings and samples, No equipment or system for which shop drawings and/or samples are required, shall be ordered or installed unless all such drawings and/or samples are duly reviewed and approved by the Engineer. The Contractor shall, upon the request of the Engineer provide plain paper copies of the standards' extracts to which references are made in the specifications.

Two copies of the brochures submitted shall be originals as published by the Manufacturer. Other copies may be clear plain paper copies. Submitted brochures shall include at least two copies of Manufacturer's original publications, other copies may be clear plain paper copies.

E-1M "As-Built" Drawings:

"As Built" drawings shall be submitted and duly reviewed and approved by the engineer.

E-1N Operation, Maintenance & Spare Parts Manuals:

The Contractor shall provide the Employer with 3 complete sets of operation & maintenance manuals covering step by step operation and maintenance aspects of all electrical equipment, as applicable. These manuals shall also include information for ordering spare parts for such equipment.

E-1O Nameplates:

Nameplates in Arabic and English shall be installed on all devices or pieces of equipment for which the use or identification may not be readily apparent, such as, but not limited to, starters, relays, contactors, controls, pushbuttons, indicating lights, switches.
Nameplates shall be made of laminated sheet plastic, 2.5 mm thick, or of anodized aluminum, approximately 1.5 mm thick, engraved to provide white letters on a black background, and fastened in place with corrosion-resistant screws, or as specified by local authorities.

Nameplates shall also be provided on all manufactured assemblies to identify the assembly as well as feeders, circuits, compartments, switches, internal components...etc..

Nameplates shall be located in a position to be easily readable after completion of the installation of the equipment. Nameplates for equipment weighing more than 15kg shall be marked giving the approximate weight to the nearest + or - 5%.

E-1P Modifications:

If during the work, the Contractor wishes to make changes or modifications, then these modifications shall be submitted to the Engineer for approval. If these changes result in extra expenses in design and/or material these expenses shall be borne by the Contractor.

E-1Q Building Management System Requirements:

The Contractor shall be responsible for co-ordination between suppliers of all equipment linked to Building Management System (BMS) in order to integrate and provide all necessary interface units inside the equipment connected to Building Management System network.

E-1R Warranty:

The Contractor shall provide appropriate warranties, where applicable, indemnifying the client against the failure of supplied goods/equipment within the prescribed period.

The warranty details shall be displayed on all goods/equipment. These details shall include:
- Warranty start and end date.
- Suppliers contact phone number.
- Local service centre

The warranty details shall be engraved on appropriate brass plates and shall be affixed to the relevant goods/equipment.

E-1S Applicable Standards:

Terminology BS 4727.

End of Sub-Section (E-1)
SUB-SECTION E-2

EARTHING SYSTEM

E-2A General:

The Earthing system shall be in full compliance with the requirements of the IEE Wiring Regulations, Local Authorities Practices and the Specifications.

Any modification required by Local authorities shall be done at no extra cost. Unless otherwise specified all materials used for earthing shall be of tinned copper or galvanized steel strip specially manufactured for the purpose.

The complete earthing system shall be electrically and mechanically continuous to provide an independent fault current return path to the earthing source.

Bolted connections shall be of the multiple bolt type. Bolts, washers and stop nuts shall be of high copper alloy. Ferrous hardware will not be accepted.

Where earthing terminal connectors are brazed to equipment, the metal shall be thoroughly cleaned prior to brazing and the impaired surfaces repainted to prevent corrosion.

The impedance of equipment (earth loop) at any point in the electrical wiring system shall be sufficiently low to limit the voltage to earth and to facilitate the operation of the circuit protective devices in the circuits, as required by the IEE Wiring Regulations. Otherwise earth leakage circuit breakers shall be used.

E-2B System Earthing:

The System Earthing shall consist of earthing pits connected in parallel if practicable, or shall consist of (3*30 MM) galvanized steel ring (counterpoise) buried under ground at a depth of 1 meter minimum around the periphery of the building or substation if the latter is a separate structure. The specified system shall be in accordance with the project layout and location as indicated on the drawings.

The earthing resistance shall be in accordance with BS 7430 and in compliance with requirements of Local Power Authorities. The main earthing bus of the main switchboard(s), shall be connected to the system earthing by a 70 mm² bare copper cable via a 40 x 5 mm main earthing bus bar fixed on the wall in an approved location.

E-2C Service Equipment Earthing:

The service equipment earthing shall be a separate earthing installation consisting of earthing pits connected in parallel. These pits shall be at least 8 meters away from the system earthing if practicable otherwise the service equipment earthing shall be bonded to the system earthing and the combined resistance shall be less than 1 Ohm.

To this installation will be connected: the ring main unit earthing bar, the transformer(s) and HT switchgears, HT cable sheaths, all exposed structural metal works including metal cable trays when the substation is situated above a basement.

Connection material and sizes shall be as approved by the Local Authorities.

E-2D Equipment Earthing of the Electrical Works:

Equipment earthing of the Electrical Works shall consist of bonding all non-current carrying metal parts of the Electrical installation to the System earth (TN -S system as per IEE Wiring Regulations, latest edition).
Non-current carrying metal parts of the electrical installation shall include such items as cabinets, exposed metal parts of apparatus as well as enclosures, doors, grill, etc., protecting or shielding electrical equipment from direct access to unauthorized personnel.

The series earthing of one piece of equipment to another will not be permitted. All equipment earthing connections shall be tapped from the applicable earth source.

The cable armouring shall not be accepted as equipment earthing conductor.

All socket outlets, power apparatus, lighting fixtures and switches shall be earthed.

**E-2E Protective Conductors:**

Earthing wires (protective conductors) are not shown on the Drawings. All circuits running in conduits or in flexible conduits shall have earthing insulated conductors of minimum sizes as follows:

<table>
<thead>
<tr>
<th>Current carrying conductor</th>
<th>Earthing Wire (protective conductor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S (mm$^2$)</td>
<td>SP (mm$^2$)</td>
</tr>
<tr>
<td>S less than or equal to 16</td>
<td>S</td>
</tr>
<tr>
<td>S greater than or equal to 16 but less than or equal to 35</td>
<td>16</td>
</tr>
<tr>
<td>S greater than 35</td>
<td>0.5 S</td>
</tr>
</tbody>
</table>

**E-2F Earthing Pit:**

The earthing rod shall be constructed from copper clad steel rod. Copper sheath shall be 99.9% pure electrolytic copper. The steel core shall be of carbon steel, with tensile strength min 97,000 psi yield strength at 0.2% offset 85,000 psi, proportional limit 57,000 psi, percent of elongation 13%. Rod shall be cold drawn.

*End of Sub-Section (E-2)*
SUB-SECTION E-3

CONDUITS AND FITTINGS

E- 3A General:

The Contractor shall supply and install a complete conduit system as shown on the Drawings and as herein specified. The system shall include conduits, fittings (couplings, bends, boxes, cover plates, reducers, adaptors, etc.) and all necessary parts to install a complete conduit system.

Conduits and fittings shall be distinctively marked as manufactured for electrical purposes.

Conduit runs are shown diagrammatically to outline the general routing of the system. The installation shall be made to avoid interfering with pipes, ducts, structural members, or other equipment. Should structural or other interferences prevent the installation of the conduits, or setting of boxes, cabinets, or other electrical equipment, as indicated on the Drawings, deviations must be approved by the Engineer, and after approval, shall be made without additional charges. The number of conduits shall not be less than that indicated on the Drawings.

Conduits and conduit fittings shall be so designed and constructed that they ensure reliable mechanical protection to the cables contained therein, and shall withstand the stresses likely to occur during transport, storage and installation. They shall be marked with the marker’s name or trade mark. Marking shall be indelible and easily legible.

Conduits shall have a minimum 20 mm (outer diameter) size and shall be adequate for proper and easy wire pulls, and in no case shall the wires occupy a cross-sectional area of more than 30% of the inner conduit cross-section.

The inside and outside surfaces of conduits shall be smooth and free from burrs, flash, and similar defects. Thickness of wall shall be uniform.

The interior and ends of conduit fittings shall have no sharp edges; surface and corners over which the cables are likely to be drawn shall be smooth and well rounded.

Conduits and fittings shall have adequate mechanical strength. Conduit when bent or compressed, or exposed to impact or extreme temperatures, either during or after installation, shall show no cracks and shall not be deformed to such an extent that introduction of the cables are likely to be damaged while being drawn in.

Conduit entries of fittings shall be so designed that a reliable joint can be made between the conduit and the fittings.

Conduits and fittings shall be BS tested or approved equal.

All accessories and fittings such as bends, straps, double straps, junction boxes, bushes, etc. shall be provided as required.

E-3B Conduits and Fittings-Non-Metallic:

Non-metallic conduits shall be heavy gauge, high impact rigid PVC Type A (Metric) or Type AH (Imperial) unless otherwise indicated, having a maximum continuous service temperature of 70 degree C or more.


E-3C Conduits - Flexible:

Flexible conduit shall be constructed by square locked galvanized steel with a PVC outer covering.
E-3D Boxes - Non-Metallic:

Boxes shall be standard PVC as specified under Conduits & Fittings or phenolic material except for recess lighting outlets which shall be High Degree type.

High Degree type boxes shall be manufactured from Noryl, a thermoplastic with a higher softening temperature. Boxes shall withstand a 10 kg. load directly suspended at 100 °C for 24 hours. Boxes shall incorporate pillars with threaded steel inserts.

All boxes shall be provided with earth terminals.

E-3E Installation of Conduits:

Conduits embedded in ceiling slab, in walls and under floor shall be non-metallic type. Conduits exposed above false ceiling shall be non metallic type.

Exposed conduits other than above false ceiling shall be rigid steel type. Fire proof.

All conduit work and plastering shall be complete before wires are pulled in unless otherwise permitted by the Engineer. Conduit shall be plugged with cork and boxes covered appropriately to avoid filling with plaster.

Conduit runs between outlets shall not contain more than three quarter bends or equivalent. The maximum run between two outlets shall not exceed 25 meters for straight runs and 10 meters for runs with one or more bends. Pull (draw in) boxes shall be provided otherwise whether so indicated on the Drawings or not. Location of pull boxes shall be approved by the Engineer.

Conduits shall be installed without causing any damage to the structural members.

All bends shall be carefully made to prevent distortion of the circular cross-section. Bends made on site in conduits shall have an inside radius of not less than nine diameters.

Where bends of less than nine diameters are necessary, standard factory elbows shall be used: however the conduit size chosen shall be such as to permit a cable-bending radius within the factory elbow of at least eight times the cable diameter.

Conduits in slabs shall be installed as close to the middle of the concrete slabs as practicable without disturbing the reinforcement. The outside diameter shall not exceed one third of the slab thickness, otherwise the Contractor shall install the cable exposed on the concrete slab by approved method according to site conditions. Conduits shall be placed not closer than three diameters on centers.

Conduits in slabs shall be placed parallel to the main reinforcement steel in the slab.

Top of any conduit in slabs shall be at least 2 cm below the finishes floor surface, unless otherwise indicated or authorized.

Conduits in slabs running parallel to beam axis shall not run above beams.

E-3F Exposed Conduits:

Exposed conduits shall be installed parallel or at right angles to walls and ceiling beams. All changes in direction shall be made as far as possible with approved bends, elbows, and pull boxes.

The spacing between parallel runs shall be uniform throughout. Unless otherwise indicated conduits shall be held securely in place by standard factory spaced bolt saddles, spaced not more than 1.5, 2.0 and 2.4 meters for 20 mm, 25 mm and 32 mm and larger conduit sizes respectively for metallic conduits and at 1 meter for non-metallic conduits.
Unless otherwise indicated, raceways exposed above false ceilings shall be supported from the slab above the ceiling in the same manner as exposed raceways. Raceways shall not be supported from false ceiling supports.

Couplings, expansion couplings, strap saddles, spacer bar saddles, spring clip saddles, conduit clips, adaptors, etc. shall all be standard factory conduit accessories.

Flexible metallic conduits shall be used only for connections to motors, or to other equipment subject to vibration or adjustment. Each connection shall contain at least one quarter bend so that no vibration can be transmitted behind the flexible connection. Flexible PVC conduits shall be used to make connections to lighting fixtures in false ceiling.

In damp and wet locations all couplings, expansion coupling, strap saddles, spacer bar saddles, spring clip saddles, conduits clips, screws, adaptors shall be corrosion proof, approved for use in damp and wet locations.

In damp and wet locations flexible conduits shall be liquid tight.

In damp and wet locations the entire conducting system, including boxes, fittings, panelboards etc. shall be mounted so that there is at least 7 mm air space between it and the wall supporting surface.

All conduits shall be carefully cleaned before and after installation. All ends shall be reamed free from burrs, and inside surfaces shall be free from all imperfections likely to injure the cable.

After installations of each complete new conduit run, the run shall be snaked with a band to which shall be attached an approved tube cleaner equipped with an approved cylindrical mandrel of a diameter not less than 85 percent of the nominal diameter of the conduit. All conduits through which the mandrel will not pass shall be removed and replaced by the Contractor at his own expense.

All field cuts in conduits shall be square, and cut ends shall be filed and shall have burrs removed. An insulating bushing shall be installed on each end of conduit, unless the connector is designed to prevent contact with the cut end. All connections shall be mechanically strong and tight, and made up properly with approved connectors. No running threads shall be permitted.

Conduits for TV system shall have at least 10 cm bending radius. Two bends might be necessary for the transition from floor to wall.

**E-3G Installation of Boxes:**

Boxes of ample capacity shall be provided at every junction of conduit system and as required by the Specifications.

All boxes shall be securely fastened.

Blank plates shall be installed on outlet boxes in which no apparatus is installed, or the apparatus installed does not provide a suitable cover for box.

Device boxes shall be used for all wiring devices.

Non-metallic junction/pull boxes shall be used only for concealed conduit work, and for conduit work above false ceiling.

Exposed boxes for switches, socket outlets and other devices shall be cast metal boxes.

Cast metal boxes shall be installed in such a manner that the conduit connections and the casketed cover are dust tight. All unused openings shall be closed with pipe plugs and compound.
Boxes for similar equipment shall be mounted at uniform height within the same or similar area. Mounting shall be as shown on the Drawings.

Device box shapes and sizes shall be determined by the type and size of wiring devices for which they serve.

Boxes fixed inside false ceiling shall be provided with mounting brackets for rigid fixing to structure members or other means of support.

**E-3H Sleeves:**

Sleeves shall be provided for exposed conduit or cables passing through floor slabs and walls. All openings shall be sealed with mastic compound. The compound shall not cause any corrosion or harmful effects to the conduit. Sleeves passing through floor slabs shall be flush with the bottom of the slab, shall extend approximately 3cm above the surface of the floor and be watertight between sleeves and floor slab.

Sleeves passing through exterior walls and slabs shall be wall entrance seals of watertight construction.

They shall be watertight between slab and sleeve, and between sleeve and conduit and cable. These wall entrance seals shall be of malleable iron with black paint finish and PVC sleeve, with a water tight sealing gland.

Sealing gland design shall be such that they may be tightened any time after installation. Wall entrance seals shall have oversized sleeves of proper length to position the sealing-gland housing with the wall faces.

After the cable has been pulled through the duct, a seal shall be made around it within the duct with a bituminous mastic compound, making the seal watertight.

**E-3I Adhesives and Joints:**

Conduits shall be jointed and terminated utilizing the appropriate components as supplied by the conduit manufacturer.

Permanent adhesives to produce a rigid watertight joint shall be used with standard couplers and accessories.

A flexible (non-hardening) adhesive shall be used where expansion facilities are required.

**E-3J Expansion Joints:**

Expansion coupling shall be provided at every 6 meter run of exposed conduit work, at expansion joints or as required to compensate for thermal expansion and contraction of both exposed and embedded conduits.

**E-3K Applicable Standards:**


*End of Sub-Section (E3)*
SUB-SECTION E-4

WIRES & CABLES

E-4A General:

The Contractor shall supply, install and connect all wires and cables necessary for complete electrical system, as indicated on the drawings, as required and as specified herein.

E-4B Wires & Cables - Lighting & Power:

Conductors shall be of high conductivity annealed copper with concentric stranding for stranded conductors, to BS 6360, or approved equal.

Minimum conductor size used shall not be less than 2.5 mm² for power circuits and 1.5 mm² for lighting circuits.

All wires for lighting and power systems pulled inside conduits shall be single core, insulated with PVC compound, of grade not less than 450/750 volts, to BS 6004. Wires in boiler rooms (if any) shall be MICC Cables to BS 6207.

Conductors shall be solid-stranded. Flexible cords for connection of fixtures to circuit-wiring shall have finely stranded copper Conductor with PVC insulation, type NYFAF, 380 V grade.

E-4C Flexible Cords:

Cords used for water heater connections shall be of high conductivity tinned copper wires, (2.5 mm² unless otherwise indicated) insulated with ethylene propylene rubber, three cores twisted together, filled and sheathed with chloral sulphonated polyethylene (EPR CSP), 300/500 V rated, and shall withstand an operating temperature of 85 C, to BS 6500.

Cords used for pendant lighting points and between lighting outlet above false ceiling to lighting fixture shall be circular three core (1.5 mm²) silicone rubber insulated, glass fiber braided 300/300 V rated to BS 6500.

Cords used for extract fans shall be of plain annealed copper conductor (1.5 mm²), PVC insulated, circular three cores twisted together, PVC overall coverd 300/500 V rated, shall withstand an operating temperature of 70 C, to BS 6500.

E-4D Wires and Cables - Telephone:

Wires and cables shall be supplied and installed to the approval of ETISALAT. The Contractor shall attend and afford all facilities to the ETISALAT and shall take prior written approval of the adequacy of the proposed conduits for the telephone system before installation of the conduit system.

E-4E Cables - Central Antenna System:
Cables shall be coaxial type with inner conductor of solid accurately dimensioned electrolytic copper, insulation of high grade solid polyethylene, outer conductor of a longitudinally overlapping copper foil tightly enclosed in a copper-wire braiding, outer sheath of a pliable PVC.

Characteristic impedance shall be 75 ohms. Inner conductor shall have a minimum of 0.7 mm diameter.

Overall diameter of cable shall not be less than 7 mm. Cable shall have a tensile strength on outer conductor of 20 kgf for one minute.

**E-4F Cables - Fire Alarm:**

Cables of fire alarm system shall be of the mineral insulated, metal sheeted type. Cable shall have a highly compressed refractory mineral insulation (magnesium oxide) enclosed in a seamless copper sheath, overall covered with PVC and shall be installed in strict accordance with manufacturer's instructions and compliance with BS 6387 Cat. SWX.

Alternatively “FP200” cables as manufactured by Pirelli (UK) or equal may be accepted with proper cost justifications in favor of Client.

Cables shall have a minimum fire resistance complying with BS 6387 category Z.

Cable shall be supported at not more than 75 times the cable outer diameter intervals by means of approved staples, straps, hangers or other fittings to building structure or to specially designed brackets.

All cable sheathes shall be red in color and of LSF grade (Low Smoke and Fumes) complying with BS 6425 and certified by BASEC.

At termination points cable shall be provided with an approved seal immediately after stripping to prevent entrance of moisture into the mineral insulation. When cable is connected to outlet boxes, panels or fire alarm equipment, fittings shall be of the threaded-gland type with seals filled with an insulating compound approved for the atmospheric and service conditions in which the cable is used. Stripping of cable ends, installation of fittings, application of insulating compound, and terminations shall be made according to manufacturer’s instructions. Cables shall be embedded in plaster where other conduit work is concealed.

**E-4G Control Cables:**

Control cables where used underground direct burial shall comprise stranded annealed copper conductor of minimum 1.5 mm² cross-section insulated with high dielectric polyvinyl chloride, nylon sheathed with a tape binder applied over the assembly, overall PVC jacketed.

Number of conductors shall be equal to the maximum number of functions plus 20% spare. Cable shall be 300/500V insulation grade.

Junction boxes shall include all necessary terminal connector boards with proper labels. Contractor shall make sure that the cross-sectional area of the conductors are sufficient to cater for the voltage drop due to the long runs involved.

Control cables where used in ducts underground or in conduits above ground shall comprise stranded annealed copper conductor of minimum 2.5 mm² cross-section for cables in ducts and 0.75 mm² for cables in conduits insulated with high dielectric polyvinyl chloride, and PVC sheathed.

**E-4H Installation of Wires & Cables:**
All wires shall be installed in accordance with the applicable provisions of the approved codes and as indicated on the Drawings.

The number of wires and sizes of conduits indicated on the Drawings is a guide only and are not necessarily the correct number and sizes necessary for the actual equipment installed. The Contractor shall install as many wires and conduits as required and necessary for a complete electrical system, and shall provide adequately for the equipment actually to be installed.

Where more than one conductor is used per phase, each phase, neutral if any and ground wires shall be run in each metallic or non metallic conduit.

Conductors shall be continuous from outlet to outlet and no splices shall be made except within outlet or junction boxes.

At every outlet and pull box, wires and cables passing through shall be left slack by an amount equivalent to 15 cm of cable length to allow inspection and connection to be made therein.

No cable bend shall have a radius of less than eight times its diameter.

The Contractor shall not change any circuit number, especially from a phase to a different phase. If such a change is necessary due to modification on site, the Contractor shall bring this matter to the attention of the engineer.

All conductors to be contained within a single conduit shall be drawn in at the same time.
A wire pulling compound shall be applied to conductors being drawn through conduit. Pulling compound shall be soap tone or other approved material.

Only cables forming part of a lift installation if any may be run in a lift shaft.

Wires and cables for feeders, sub-feeders, control, and branch circuit wiring shall be colour coded as follows:

<table>
<thead>
<tr>
<th>Color</th>
<th>Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>A or 1</td>
</tr>
<tr>
<td>Yellow</td>
<td>B or 2</td>
</tr>
<tr>
<td>Blue</td>
<td>C or 3</td>
</tr>
<tr>
<td>Black</td>
<td>Neutral</td>
</tr>
<tr>
<td>Green/yellow</td>
<td>Equipment grounding</td>
</tr>
</tbody>
</table>

Wire and cable sizes shall be as indicated on the Drawings; however in no case shall their size be smaller than required by the approved Code.

Unless otherwise indicated, no conductor for lighting and power wires shall be smaller than 2.5 mm².

All branch circuits for lighting and appliances shall be single conductor cables run inside conduits, unless otherwise indicated.

Feeders and sub-feeders shall be either single conductor wires pulled inside conduits or multi-conductor cables run exposed on walls or in trenches as shown on the Drawings.

Single cables shall be fixed directly to walls or ceilings. Where 2 or more cables are run in parallel, they shall be fixed on galvanized steel perforated trays or on other approved special cable supporting and protecting arrangement.

Cables shall be fixed to supporting structures with approved galvanized cast steel clamps at distances not exceeding 20 diameters. No joints or splices shall be accepted on main feeders.

E-4I Identification of Wires & Cables:
Individual conductor or circuit identification shall be carried throughout, with circuit numbers or other identification clearly stamped on terminal boards and printed on directory cards in distribution cabinets and panel boards.

In junction boxes, cabinets, and terminal boxes where the total number of control, indicating, and metering wires is three or fewer and no terminal board is provided, each wire including all power wires, shall be properly identified by means of a plastic-coated, self-adhesive, wire marker. Wires including motor leads and other power wires too large for connection to the terminal boards shall be identified by wire markers as specified above.

In manholes, handholes, pull boxes, junction boxes and at both terminals each wire and cable shall be properly identified by a laminated plastic tag located so as to be easily seen. Wires and cables shall be identified by cable number indicated on the Drawings.

E-4J Connectors and Terminal Blocks:

For the wiring of circuits consisting of wire sizes 6 mm² and smaller such as for lighting branch circuits, self-insulated pressure type connectors shall be utilized for all splices or joints.

For the wiring of circuits consisting of wire sizes 10 mm² and larger shall be of the bolted pressure type with a preinstalled sleeve.

Connectors shall be manufactured from high conductivity copper, electro tin-plated. Connector bodies shall be manufactured from Polyamide.

E-4K Cable Ladders:

Cable ladders shall be manufactured from Mild steel, with hot-dip galvanized finish. The steel thickness shall be according to the size of the ladder and application. It shall conform to BS 1449 Part 1.

All parts like flat elbows, offset reducers, straight reducers, cross pieces, tee pieces, drop outs, etc. as well as accessories shall be furnished as to function, and to the manufacturers standards.

E-4L Cable Glands:

Cable glands shall be provided at the termination of armoured cables at the enclosure of a distribution board or any other equipment. Whether installed indoors or outdoors, all cable glands shall provide protection to IP 55 as a minimum.

Glands for armoured cables shall be made of brass and incorporate an armour clamp and compression type neoprene rubber seal over the inner sheath. For cable glands which may be exposed to rain or spraying water (e.g. due to hosing down) an additional neoprene compression seal over the outer sheath shall be also provided.

E-4M Applicable Standards:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5.</td>
<td>Specification for PVC insulated non armoured cables</td>
<td>BS 6004:1995</td>
</tr>
<tr>
<td></td>
<td>Integrity under fire conditions</td>
<td></td>
</tr>
</tbody>
</table>

End of Sub-Section (E-4)
SUB-SECTION E-5
WIRING DEVICES

E-5A General:

The Contractor shall supply and install all of the wiring devices as indicated on the Drawings and as herein specified.

Wiring devices shall be flush mounted type, unless otherwise noted and shall be installed at heights as shown on the Drawing, or as directed by the Engineer.

Wiring devices fixed on glazed tiles shall include a rubber gasket between the cover plate and the glazed tiles for rigid fixing of the device plates. The gaskets shall not protrude beyond the plate: they shall be neatly cut in the shape of the plate.

Samples of devices and plates shall be submitted for choice and approval of the Engineer.

E-5B Device Plates:

Plates shall be rectangular or square in shape to the approval of the Engineer. Plates shall be designed to match associated devices.

Plates for cord extension shall be provided with cord grip bushings, threaded type, of same material and finish as of plate.

Unless otherwise specified or indicated on the Drawings, plates for flush mounting devices shall be constructed of molded material of ivory or white in color in general areas.

Fixing screws shall be chromium plated and polished. Screw heads shall be finished to suit the plates.

E-5C Switches:

Switches shall be rocker operated mounted with the operating handle in the upward position when in the "ON" position unless otherwise directed by the Engineer. Legrand or equivalent.

Switches shall interrupt the hot wire or hot and neutral simultaneously as applicable.

Switches shall be quick-make, quick-break, with silver alloy contacts, trunnions and spring assembly lubricated for the life of the switch neoprene bumpers.

Switches shall be 250 volt AC only rated with number of poles and 10 Amp ratings as indicated on the Drawings, to BS 3676 Part 1.

Switches shall be fully rated for tungsten filament and fluorescent lamp loads, and up to 80 % of rated capacity for motor loads.

Lighting switches shall be as manufactured by MK (UK), Crabtree (UK), or approved equal.

Switches shall be one gang or multi gang, 1-way, 2-way or intermediate as indicated on the drawings and to the approval of the Engineer.
Key operated lighting switch shall be 20 amp rated, one way single pole, similar to MK 4898, Crabtree 4451 to the approval of the Engineer.

20-Amp double pole switches shall incorporate a pilot light, and shall have the words “Water Heater” engraved on it when used for that propose.
20-Amp double pole switches shall be similar to MK 5423, 5423/WH Crabtree 4015/3, 4015/31 to the approval of the Engineer.

32 Amp double pole switches shall be similar to MK 5105/WH1 or Crabtree 4013/3, to the approval of the Engineer.

30-Amp double pole switch shall incorporate the inscription indicating the purpose of its use.

45/50-Amp double pole switches shall incorporate a pilot light, and shall have the word “Cooker” engraved on it when used for that purpose.

45/50-Amp double pole switches shall be similar to MK 5215/WH1, Crabtree 4500/3, 4500/31 to the approval of the Engineer.

**E-5D Switch Panels:**

Switch panels shall be of the grid switch system, comprising rocker-operated grid switches and Cover plates of molded material with white finish, unless otherwise indicated.

Switch panels shall comprise 20-amp lighting switches, and other units if so indicated on the Drawings.

Switches shall be similar to MK 4891, 2, 3, Crabtree 4450, 4550, 4552, 4535, to the approval of the Engineer.

Switch assemblies shall have the words “Danger 415 volts” engraved in red in it.

Cover plates shall be similar to MK 3631, 2, 3, 4, 6 & 8 Crabtree 5571, 2,3,4,6, unless otherwise specified or indicated on the Drawings, to the approval of the Engineer.

**E-5E Timer Switches:**

Timer switches shall be 20-amp rated, one pole, one throw with one “OFF” and one “ON” levers. Switch shall be 30 minute dial type, recess mounted. Switches shall have 20,000 switching cycles guaranteed life.

**E-5F Lighting Contactor Control Pushbuttons:**

Pushbuttons shall be double contact type with spring return action. Legrand or equivalent.

Body shall be made of molded plastic with clear baked acrylic protection.

**E-5G Socket Outlets:**

Socket outlets shall be mounted with correct polarity, such that switch shall cut the hot wire.

Socket outlets shall be of the standard, 3-pin, switched, single phase, shuttered type of molded plastic unless otherwise specified. Legrand or equivalent.

13-amp socket outlets shall be flat pin type, to BS 1363, single or twin as indicated.

13-amp socket outlets shall be similar to MK 2757WH1, 2747WH1, Crabtree 4304, 4306 unless otherwise specified or indicated on the Drawings, to the approval of the Engineer.
15-amp socket shall be round pin switched type to BS 546.

15-amp socket shall be similar to MK 2893WH1, Crabtree 2382, to the approval of the Engineer. Flush mounted fire proof three phase compound type boxes, provided by three phase socket (16A, 25A, 32A, ..63A). Should be complete with protection circuit breakers and one single phase socket.

E-5H Ceiling Roses:

Ceiling roses shall be designed to meet the requirements for the installation of flexible pendant cords for lighting. They shall be molded in a non-track insulating material to BS 1323 and shall comply with BS 67 and IEE Wiring Regulations.

Ceiling roses shall incorporate 3 terminals (one of which properly shrouded), loop-in, earth and strain. The shrouded terminal shall be used for the live un switched wires.

Ceiling roses shall be similar to MK 1161, Crabtree 5860, 5861 or approved equal to the approval of the Engineer.

All lighting fixtures incorporated in a false ceiling shall be connected to the ceiling lighting outlet through a ceiling rose and a flexible cord.

E-5I Fan Coil Power Outlet/Fused Connection Unit:

Power outlets for fan coil units ceiling mounted shall be flush surface mounting 13-amp fused connection units incorporating double pole switch, neon indicator and fuse of appropriate rating, in a 2-gang device box, with the second gang covered with a blank plate.

Device shall be similar to MK 370WH1, Crabtree 4827/3. Blank plate shall be similar to MK 3827; Crabtree 4001 and the device box shall be similar to MK 2025, Crabtree 9047, all to the approval of the Engineer.

Outlet shall be an Electricaire control unit similar to MK 5300, to the approval of the Engineer.

Outlet for fan coil units installed at low level shall be a recess mounting 13-amp fused connection unit incorporating a double pole switch, neon indicator, fuse of appropriate rating and flex outlet.

Outlet shall be similar to MK 370 WH1, Crabtree 4827/3 to the approval of the Engineer.

E-5J Telephone outlets:

Telephone outlets shall be cord grip type and shall consist of terminal blocks of high insulating phenolic block with non-ferrous screws and straps.

Telephone outlets shall be similar to MK 4817WH1, Crabtree 7283, unless otherwise specified or indicated on the Drawings to the approval of the Engineer.

E-5K TV Outlets:

TV outlets shall be of molded material and shall have a low attenuation (1 db) for all frequencies.

TV outlets shall be manufactured by the same manufacturer of the TV System and to the approval of the Engineer.

E-5L Control Stations:

Control stations shall be spring type, with silver plated contacts. Contacts shall be 5 amp rated. Plate shall be constructed from aluminum gray baked enamel painted.
ON-OFF maintained contact station shall have two pushbuttons, one green for ON and one red for OFF. A green pilot light shall be incorporated which shall lit when pushbutton ON is depressed. The words ON & OFF shall be engraved on the pushbuttons in white.

START-STOP momentary contact type station shall have two pushbuttons, one green for START and one red for STOP. A green pilot light shall be incorporated which shall lit when pushbutton START is depressed. The word START & STOP shall be engraved on all motor control stations.

UP-STOP-DOWN momentary contact type stations shall have three pushbuttons and no pilot lights.

Pushbuttons shall be molded from trac-resistant material, and shall be provided with button shrouding ring.

Key switch shall be a cylinder lock operator type station with three positions UP-OFF-DOWN. These words shall be engraved on the station.

Stations in damp & wet locations shall be enclosed in a Ferroalloy box and covered with stainless steel plates.

When line voltage is 380-415 and the control is line-to-line connected as described under MOTORS & STARTERS', a warning notice shall be inscribed in the device in a clearly visible manner once the cover is removed.

E-5M Flex-Outlet:

Flex-outlet shall be similar to MK 1090, Crabtree 4075 unless otherwise specified or indicated on the Drawings, to the approval of the Engineer.

E-5N Cable Outlet:

Cable outlet shall comprise a molded cover plate with a side groove for 3x10 mm² multi core flexible cords, a cable clamp, 3 terminals for 10 mm² conductors.

Cable outlet shall be similar to Crabtree 4506, MK 5045 to the approval of the Engineer.

E-5O Fireman's Emergency Switch:

Fireman's emergency switch shall be 16 Amp double poles or four poles as applicable. It shall incorporate a neon light. Opening of cover shall not be possible when live.

It shall be protected against dust and splash of water to IP54.

It shall be similar to Legrand 380 39, 380 41 or approved equal.

E-5P Application Standards:
2. Specification for 13A fused plug and socket outlets - BS 1363:1984
4. Specification for Transformers for reduced voltage - BS 3535:1990
5. Specification for Lighting Switches - BS 3676
6. Specification for Dimmers - BS 5548

End of Sub-Section (E-5)
SUB-SECTION E-6

MAIN DISTRIBUTION BOARDS

E-6A General:

The Contractor shall supply and install the Main Distribution Boards (MDB-XX) as shown on the Drawings and as herein specified. The equipment shall include bus bars, circuit breakers and/or fusible switches, and all necessary parts to install a complete distribution board, as shown on the Drawings and as herein specified.

The equipment shall be suitably constructed for safe, proper and reliable operation without undue wear, corrosion, heating or other operating trouble.

The design, form of construction and arrangement details of the equipment shall be as indicated on the drawings and to the approval of the Engineer.

The arrangement of the equipment within the assemblies shall be individually-mounting type in a modular arrangement and shall be such as to afford maximum accessibility to all parts, incoming and outgoing wires and cables.

The assembly shall be completely wired and tested at the factory, ready for installation when received at the site. Bracing shall be provided to prevent distortion in handling and transportation.

The assembly shall be rated for a 600 volt duty.

The assembly shall be suitably braced for the short circuit duty shown on the Drawings, at nominal operating voltage.

Approved nameplates, permanently mounted for identification of all major and control equipment shall be provided as described under “GENERAL”.

The enclosure and other steel works of (MDB-XX) shall pass through a four stage finishing process such as chemical spray, degreasing, iron phosphating and finally give a top coat of polyester powder electro statically deposited and cured in a high temperature oven to give a strong molecular bonding with the steel. The final color of the enclosure shall be as per the manufacturer’s standard. All steel screws, nuts, bolts, shall be zinc plated and passivated to prevent rusting.

All components of the assembly shall be the product of a single manufacturer who shall also perform all assembly work.

Structural steel base shall be provided for securing entire assembly to floor.

The design, manufacturer’s selection, installation, testing, commissioning, connection and future maintenance of all equipment and materials described in this specification shall comply with the requirements of BSEN 60439-1(1994), the local Power Supply Authority regulations, the IEE Wiring regulations and the documents referenced in each of these publications.

The Contractor must at an early stage provide the Engineer with all the necessary manufacturer's details and shop drawings concerning the assembly to allow him to check the design of the concrete structure, particularly concerning the loads, the overall dimensions and the cable grouting holes.

Main distribution board that are directly fed from transformers of the Local Electrical Authorities shall comply with all the requirements of these Authorities. The Contractor shall modify the specified distribution boards to meet these requirements at no extra cost. Main distribution boards should have satisfactory ventilation fans.
E-6B Construction of the Assembly:

Unless otherwise indicated, the assembly shall be of the indoor casketed type of size, rating and arrangement as indicated on the Drawings. The complete assembly shall be ground mounting type with matching cases to form continuous internal structure.

The assembly shall consist of a completely enclosed self supporting metal structure, containing circuit protective devices and all other associated equipment as indicated on the Drawings and/or specified under other Clauses.

The assembly shall consist of the required number of formed and welded sheet steel enclosures required to mount circuit protective devices and other equipment.

Bolted frames shall be provided at the rear to support and house copper bus bars, cables and other accessories.

Front, side and top plates shall be steel, removable and not less than 1.5 - 2 mm thickness.

All fastenings between structural members shall be bolted, not welded to provide flexibility during installation.

Removable panels shall be provided at the front of each vertical section.

The arrangement shall permit cables to enter from bottom and top of the enclosure and connect to their respective terminals without interference. The assembly shall be provided with cable racks and bolting down holes.

A modular individual mounting arrangement (in Form as indicated on the drawings) shall be used and the internal separations shall be carried out using rigid barriers or partitions.

Structure and buses shall be arranged to permit future sections to be added. Suitable cover plate must be provided for temporary protection.

The assembly shall be vermin and rodent proof. Protection shall be to IP41 as a minimum requirement unless otherwise indicated on the Drawings.

E-6C Bus bars:

Main horizontal bus bar ratings as shown on the Drawings shall be provided across the top of each structure. Each structure shall also be complete with vertical copper buses to distribute incoming power to each outgoing protective device in the structure. The distribution board bussing shall be plated and sleeved as per authorities requirements and of sufficient cross-sectional area to continuously conduct rated current with a maximum average temperature rise of 20 degree C above an ambient temperature of 50 degree C.

Each phase and neutral bus bar shall be tin plated and shall consist of hard drawn, high conductivity copper of uniform rectangular cross section throughout to BS 1433.

All bus connections shall be bolted and clamp type terminals provided for cables.

All bus bars and bus bar connections shall be accessible for inspection and maintenance only, after the removal of covers secured by bolts and studs. Such covers shall be identified externally by Engraved laminated labels bearing the inscription; “Bus bars - Danger 380 volts” in 30 mm high black lettering on yellow backing round.
Neutral shall be full size, unless otherwise indicated. No Diversity shall be used in Bus Bar dropper sizing.

Earthing bus shall be sized in accordance with the BS 7430 for prospective short circuit.

Grounding (earthing) bus shall extend through the entire length of the assembly.

Main Distribution Board that is fed directly from the transformer shall have the following additional features:

a) Neutral bus bar shall be provided with a removable solid bar link for testing purposes.

b) A separate bonding strap shall be connected from the neutral bus to the main distribution board frame. This bonding strap shall be located on the line side of the removable neutral link maintaining a service ground to the main distribution board frame when the test link is removed.

c) Any additional feature as per the Electrical Authorities requirements.

The MDB shall be type tested in accordance with BSEN 60439-1 copy of test certificate from independent laboratory confirms that all type tests mentioned under BSEN 60439-1 are passed, shall be submitted.

E-6D Labels:

All enclosures containing functional units shall be clearly labeled with a circuit unit reference and current rating in English and Arabic. Every functional unit shall be labeled separately from all others. External labels shall have letters not less than 5 mm in height and internal labels not less than 3 mm. The letters shall be black in color on white background.

All covers / doors not fitted with interlock switched disconnectors enclosing unshrouded live equipment shall be fitted with warning labels inscribed "Danger-Isolate before Opening" in English and Arabic.

Warning labels shall have black letters on bright yellow background. Whenever possible, letters shall be not less than 30 mm in height. On small covers and doors 20 mm or 10 mm high letters shall be used.

All terminal blocks shall be labeled relative to respective functional unit. Every control and metering device, switch, pushbutton, indicator lamp, etc shall be labeled to indicate its purpose.

Main identification labels shall be provided on the assembly together with its rating plate.

Fixed and with draw able portions of equipment, including fixed and plug in devices shall be labeled with both with draw able and fixed part.

E-6E Selector Switch/Push Buttons / Indicator Lamp:

Selector switches shall be of the rotary type with lever or key operated actuators as specified in the schedules. Push button shall be of the flush type with colors in accordance with BSEN 60043:1993.

Pushbuttons for emergency stop purpose shall be of mushroom head type, with twist to release action or key reset facility as specified.

Contact blocks shall have double break silver plated contacts in NO or NC configuration rated at not less than 5A resistive at 220V, 50Hz.
Indicating lamps shall be of the flush type, 22 mm diameter, with removable colored lenses to permit replacement of lamps from the front. Colors shall be in accordance with BS 4094.

Indicating lamps on control circuits shall be equipped with completely sealed dual wound safety isolating transformers. Lamp test facility shall be provided.

**E-6F Testing and Commissioning:**

The main distribution board assembly shall be tested at factory in accordance with the requirements of BSEN 60439-1 and the associated standards.

Work tests shall include inspection of all components, wiring and a complete electrical functioning test.

Protection relays shall be tested by primary current injection method, with currents equal to overload, short circuit and earth fault conditions.

After completion of installation of the switchgear assemblies on site, they shall be subjected to the routine tests as defined in BSEN 60439-1.

All functional units shall be checked for correct mechanical operation.

Following the satisfactory conclusion of inspection and tests both at factory and on site, each assembly shall be duly commissioned and left in full working order. The commissioning process shall be deemed to include the following:

1. Energizing of functional device circuit and equipment which have been inspected, megger tested, found satisfactory and capable of being energized with complete safety.
2. Starting up of all electrically powered plant and equipment including those supplied and installed under other sections of the contract.
3. Verification of the performance of each switchgear assembly relative to all such plants and equipment by carrying out functional tests, where required and making necessary adjustments for optimum performance.
4. Testing interlock options in all possible combinations and operations of control system.

**E-6G Circuit Breakers:**

Circuit breakers shall be molded case type, totally front accessible and front connectable. The breakers shall be mounted in the distribution board to permit installation, maintenance and testing without reaching over any live side bussing.

Circuit breakers shall comply with IEC 947-2 (EN 60947-2) and short circuit category ICS.

Test certificate from independent laboratory to certify that the MCCB’s comply with the IEC-947-2, (EN60947-2) test sequence -2 shall be submitted when required by Engineer.

All line and load side connections shall be individual to each breaker. No common mounting of electrical bus connectors will be acceptable. Line side breaker connections shall be bolt-on type. Breaker connections requiring leaf and coil springs which could loosen or fly apart during a fault are not acceptable.

Frame shall be constructed from molded moldarta and/or glass polyester material.

The operating mechanism shall be toggle type quick-make, quick-break, trip-free, with three different positions for ON, OFF & TRIP.
Circuit breakers shall incorporate an arc-extinguishing compartment such that when the contacts are opened, the arc drawn shall induce a magnetic field in the grids, which in turn, shall draw the arc from the contacts and into the grids, thus splitting the arc into smaller arcs and extinguish very rapidly.

The trip element shall be a bi-metal for overload and an electromagnet for short circuit.

Molded Case Circuit Breakers (MCCB) breakers shall be electronic type with adjustable, setting for overload and short circuit. The breaker should have a facility to test the tripping circuit of the MCCB by inducing an electrical pulse from portable unit.

Breakers shall be manually operated with store energy spring load.

Breakers shall be ambient compensated type with a built-in compensator to carry rated load at 50 degrees centigrade.

Breakers shall have 415/380 volt duty rating, and a minimum symmetrical short circuit interrupting rating equal to 50 KA for main distribution boards associated with (1000, 630, 500) KVA transformers.

Each breaker shall be supplied with an externally operable mechanical means to trip the circuit breaker.

Key interlocks for circuit breakers where indicated shall incorporate a plunger that blocks the breaker in the open position. Key removal shall be possible in such a way to achieve the desired interlocking system.

Where required, breakers shall be suitable for bus way connection.

Main breaker shall be insulated case type provided with interchangeable trip units, current transformers, flux-transfer short trip and solid state circuiting.

**E-6H Air Circuit Breakers**:

Air circuit breakers shall be totally with draw able type completely self-contained in an enclosed housing to be mounted in a switchboard cubicle without additional screening. It shall occupy a complete section, completely segregated from all other parts of the switchboard. Vent holes shall be provided in the side of the circuit breaker housing to provide thermal ventilation and also to permit easy air flow through the arc chutes when interrupting a short circuit. The circuit breaker shall be installed in an enclosure greater than twice the breaker volume.

Air circuit breakers shall be equipped with solid state microprocessor based protection unit.

The protection unit shall not require any external power supply. It shall have adjustable long time protection for overload, adjustable instantaneous short circuit protection and earth fault protection for the incoming air circuit breakers. The outgoing air circuit breakers shall have adjustable long time protection for overload and adjustable instantaneous short circuit protection only. The protection unit shall have magnetic trip indicator and shall be adjustable for ambient temperature up to 70 degree C.

Operating mechanism shall be of the trip free spring assisted hand closing type. It shall include a slow close feature for checking contact operation and adjustment. A flag type indicator shall indicate the ON or OFF position.

Air circuit breakers shall be of the triple pole or four-pole as specified in the schedules or as indicated on the drawings. Where four pole breakers are called for, one pole shall be a full sized switched neutral.
The air circuit breaker shall be closed and opened by a stored energy spring charged operated, mechanism. The operating mechanism shall be designed in such way that the excess energy at the end of a closing cycle is used to partially recharge the closing spring. Also the opening springs shall be automatically charged during the closing operation.

The air circuit breaker shall in addition have adjustable short time delay in both current and time directions, and adjustable instantaneous trip in the current direction.

All contacts subject to arcing shall be tipped with arc resistant material and shall require minimum maintenance after short circuit interruption. The main contacts shall be silver faced to ensure complete reliability in service under onerous current loading or ambient conditions.

The arc chutes shall be of special design employing steel splitter plates. The plates shall be arranged so that the arc is rapidly de-ionized while it is contained within the chute structure and the plate spacing shall be such that back pressure is minimized. The complete chute assembly shall be easily removed for routine inspection of the chute and contacts.

Isolating contacts shall be multi-finger spring loaded type which shall be silver plated and shall require no attention.

A front operated racking mechanism shall cause withdrawal of breaker. Access shall be via a lower cover. Safety shutters of insulation material shall be provided to prevent access to live connections in the inspection position or when the breaker is completely withdrawn.

Interlocks shall be provided to prevent being isolated unless it is in the OFF position and also to prevent the breaker being racked into the service position unless it is in OFF position. Interlocks shall also prevent the breaker being accidentally pulled completely off the guide rail and prevent the independent manual operated breaker being “slow closed” in the service position. Provision shall be made for padlocking the safety shutters when the breaker is completely withdrawn.

Locks shall be provided to prevent access to the time lag dashpots and racking mechanism, preventing unauthorized adjustment of the trip setting, also enabling the circuit breaker to be locked in the isolated position thus disconnecting the supply.

Breakers shall be ambient compensated type with a built in compensator to carry rated load at 50o C.

Air circuit breakers shall conform to IEC-947-2 (EN 60947-2).

An earth terminal shall be provided at the rear of the with draw able breaker housing connected to a plug and socket contact, to provide an earth connection to the moving breaker portion. Contacts shall be maintained in the breaker isolated portion.

Short circuit performance shall comply with IEC-947-2 (EN 60947-2), including make-break tests at Up to 50 KA rms and 100 KA peak with minimum recovery voltages of 550 volts.

Mechanical endurance shall ensure over 30,000 operations with only minor maintenance.

A non reset able number of operation counter shall be provided.

Suitable cable glands shall be provided for the support of the incoming supply cables.

**E-61 Current Limiting Circuit Breakers:**

Current limiting circuit breakers shall have a maximum interrupting rating of 100 KA rms symmetrical amperes. All circuit breakers shall be UL listed and meet NEMA Standard No. AB1-1975 and Federal Specification W-C-375B/GEN where applicable.
Current limiting circuit breakers shall be supplied in unit molded case construction and shall consist of a common trip, thermal magnetic circuit breaker with an independently operating limiter section in series with each pole.

The conventional breaker section shall have an over center, trip-free toggle-type mechanism with quick make, quick break action and positive handle indication. A button shall be provided on the cover for mechanically tripping the circuit breaker. The current limiting breaker shall have permanent trip units containing individual thermal and magnetic trip elements in each pole. The thermal trip element shall be calibrated for 50 oC ambient temperature.

The limiter section shall consist of three current limiting elements electrically coordinated with the conventional circuit breaker trip elements. The contacts of the limiter section shall be electromagnetically and electro-dynamically opened and hold open until interruption is complete. The unit shall not contain replaceable elements and the limiter shall automatically reset after circuit interruption.

On high level fault currents the limiter portion of the circuit breaker shall operate to limit the rise of fault current. Integral resistance shall be introduced into faulted circuit to dissipate and limit let-through energy and to provide a voltage transient-free interruption at rear unit power factor unit.

The current limiting circuit breaker shall have front removable lugs. Lugs shall be UL listed for copper conductors.

E-6J Branch Circuit Breakers for Chillers:

Breakers protecting chillers shall also incorporate the following protections:
- Phase failure relay
- Reverse phase relay
- Under voltage relay
- Over current relay

All these relays shall be connected to the shunt trip circuit of the breaker.

E-6K Kilowatt-hour Metering Compartment:

In main distribution boards, where kilowatt hour meters are indicated or are implied, a separate compartment shall be provided in the distribution board for this purpose including the meter, to the approval of the local power authorities.

E-6L Shop Drawings:

The Contractor shall submit shop drawings for the distribution boards including schematic diagrams with all protective devices, control, instruments and instrument transformers details, dimensions of the assembly, etc. A copy of these shop drawings shall also be submitted to the Local Power Authorities (if required) for approval. Any modification required by the Engineer or the Local Power Authorities to allow the equipment to comply with the codes, standards and specifications called for hereinbefore shall be carried out without additional charges.

E-6M MAIN DISTRIBUTION BOARDS SCHEDULES:

SCHEDULE NO. 1 - COLOUR CODES FOR CABLES

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Cable Color</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>220 V a.c. (Single Ph. Circuits)</td>
<td>Red, Yellow, Blue, (Brown).</td>
<td></td>
</tr>
<tr>
<td>380 V a.c. (Three Ph. Circuits)</td>
<td>Red, Yellow, Blue, (Brown).</td>
<td></td>
</tr>
<tr>
<td>Neutral</td>
<td>Black, (Blue)</td>
<td></td>
</tr>
<tr>
<td>Earth</td>
<td>Green, Yellow</td>
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### SCHEDULE NO. 2 - PUSHBUTTON COLOURS

<table>
<thead>
<tr>
<th>Color</th>
<th>Application</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Stop or off</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Emergency stop with mushroom head, twist to reset and with yellow color.</td>
<td></td>
</tr>
<tr>
<td>Green</td>
<td>Start or On</td>
<td></td>
</tr>
<tr>
<td>Light Blue</td>
<td>Reset of overload devices</td>
<td></td>
</tr>
</tbody>
</table>

### SCHEDULE NO. 3 - INDICATION LAMPS

<table>
<thead>
<tr>
<th>Color</th>
<th>Application</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>1) Main circuit breaker closed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2) Equipment tripped by protective device.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3) Parameter outside safe limit.</td>
<td></td>
</tr>
<tr>
<td>Yellow</td>
<td>1) Parameter outside normal limit.</td>
<td></td>
</tr>
<tr>
<td>Green</td>
<td>1) Circuit breaker open.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2) Normal function of equipment.</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>1) Supply available.</td>
<td></td>
</tr>
<tr>
<td>Blue</td>
<td>1) Specified indication as labeled.</td>
<td></td>
</tr>
</tbody>
</table>

**E-6N Applicable Standards:**

1. Require Requirements for Type Tested and Partially Type tested Assemblies - BSEN60439-1:1994.


SUB-SECTION E-7

SUB-MAIN DISTRIBUTION BOARDS

E-7A General:

The contractor shall supply, install, test and commission Sub-main Distribution Boards complete as herein specified and as shown on the drawings.

Sub-main Distribution Board shall be equipped with thermal magnetic type molded case circuit breakers of frame size and trip ratings as indicated on the drawings.

The bus bar structure and the main breaker shall have current ratings as shown on the drawings. The main incomer shall be either an automatic or non-automatic molded case circuit breaker as indicated on the drawings.

Sub-main Distribution Board shall have, 380 V, 3-phase, 50 Hz duty rating and shall have short circuit interrupting capacity equal to or greater than the integrated equipment rating shown on the drawings.

Sub-main Distribution Board shall conform to BS EN 60439-1:1994.

E-7B Cabinets and Fronts:

Distribution board assembly shall be enclosed in a steel cabinet. Cabinet shall be of sufficient size to provide a minimum gutter space of 10 cm on all sides. The thickness of the sheet steel shall be minimum 1.5 mm.

Fronts shall include doors and have flush, brushed stainless steel cylinder tumbler - type locks with catches and spring loaded door pulls. The flush lock shall not protrude beyond the front of the adjustable indicating trim clamps which shall be completely concealed when the doors are closed. Fronts shall have approved directories with name of panel, number of phases, wires and voltage written on them. Doors shall be mounted by completely concealed steel hinges. Fronts shall not be removable with door in the locked position.

Fronts shall be of powder coated electro galvanized sheet steel. Color shall be grey to BS 381C or approved equal.

Joints shall be welded, galvanized and reinforced where necessary and galvanized after fabrication.

E-7C Sub-main Distribution Board Bus Assembly:

Bus for connections to the branch circuit breakers shall be the “Distributed Phase” or “Phase Sequence” Type.

Three-phase, four-wire bussing shall be such that any three adjacent single-pole breakers are individually connected to each of the three different phases in such a manner that two or three pole breakers can be installed at any location. All current carrying parts of the bus assembly shall be plated.

Main and neutral buses shall be minimum 98 % conductivity rectangular copper bars, provided with bolted-type lugs as necessary.

Buses shall be rigidly supported and insulated and be so designed that branch circuits can be removed without disturbing adjacent units or changed without additional machining, drilling or tapping.
Necessary bussing, drilling and blank plates shall be provided for installation of future circuits when so indicated in the Schedules on the Drawings.

All screws and bolts used for making copper connections shall be equipped with lock washers. Riveted connections will not be acceptable.

Mains shall be equipped with solder less pressure indent type connectors and have means to prevent swiveling of connector.

Neutral bus bars shall be full size and shall incorporate one neutral terminal for each single pole and neutral way.

Aluminum shall not be used for any panel board parts.

Back pan or mounting on which buses and branches are mounted shall be rigid to properly support the component parts.

Reinforcing of back pan shall be by flanging or addition of angle iron. Buses, connectors, and terminals shall be silver plated to a minimum thickness of 0.1 mm.

**E-7D Earthing:**

An acceptable terminal bar for equipment earthing conductors shall be provided with minimum number of cable terminations equal to the single pole number of ways of the panel board.

Cabinets shall be provided with an earth connector welded to it.

**E-7E Molded Case Circuit Breakers:**

Molded case circuit breakers shall have trip settings, and number of poles, as indicated on the Drawings. All circuit breakers shall have their ampere trip rating clearly marked and visible.

Breakers shall have quick-make, quick-break, toggle mechanisms; and shall provide positive trip-free operation on abnormal overloads. Stationary and movable contacts shall be adequately protected with effective and rapid arc interruption. Each pole of the breaker shall be equipped with an inverse time delay thermal over current trip element and magnetic instantaneous over current trip elements for common tripping of all poles for multiple breakers. Multiple pole breakers shall have a single handle mechanism. Automatic tripping shall be indicated by the breaker handle assuming a clearly distinctive position from the manual ON and OFF position.

Circuit breakers shall have minimum RMS symmetrical interrupting capacities at 380 V equal to the values indicated below for molded case circuit breakers unless otherwise indicated, and shall in no case be less than the bus bar short circuit bracing of the distribution board:

- 25kA up to 150A frame size
- 34kA for 225A frame size and above

Molded case circuit breakers shall comply to IEC-439-1 (EN 60439-1).

**E-7F Current Limiting Circuit Breakers:**

Current limiting circuit breakers shall have a maximum interrupting rating of 100 KA rms symmetrical amperes. All circuit breakers shall be UL listed and meet NEMA Standard No. AB1-1975 and Federal Specification W-C-375B/GEN where applicable.

Current limiting circuit breakers shall be supplied in unit molded case construction and shall consist of a common trip, thermal magnetic circuit breaker with an independently operating limiter section in series with each pole.
The conventional breaker section shall have an over center, trip-free toggle-type mechanism with quick make, quick break action and positive handle indication. A button shall be provided on the cover for mechanically tripping the circuit breaker. The current limiting breaker shall have permanent trip units containing individual thermal and magnetic trip elements in each pole. The thermal trip element shall be calibrated for 50°C ambient temperature.

The limiter section shall consist of three current limiting elements electrically co-ordinated with the conventional circuit breaker trip elements. The contacts of the limiter section shall be electro-magnetically and electro-dynamically opened and held open until interruption is complete. The unit shall not contain replaceable elements and the limiter shall automatically reset after circuit interruption.

**E-7G Sub-main Distribution Board Installation:**

Sub-main distribution board shall be aligned, leveled and securely fastened to the building.

Connecting conduits shall not be used to support the distribution board.

All unused openings in Sub-main distribution board cabinets shall be properly closed.

Sub-main distribution board interiors shall not be installed in cabinets until all conduit connections to the cabinet have been completed.

Trim shall be installed plumb and square to finish painting.

Trim for flush mounted cabinets shall be installed in plaster frame, flush with finished wall.

Concealed surfaces of cabinets shall be given on site a heavy application of emulsified asphalt prior to installation.

Free standing sub-main distribution boards when installed in electrical closets, or rooms with depressed floors shall be provided with galvanized steel support structures to raise the level of the panel to 10 cm above the original floor level.

End of Sub-Section (E-7)
SUB-SECTION E-8
DISTRIBUTION BOARDS

E-8A General:

The Contractor shall supply and install the distribution boards (DB-XX) as indicated in the Schedules, where shown on the Drawings, and as herein specified. They shall include bus assembly, cabinet and front, circuit breakers and all necessary parts to install complete distribution boards.

Distribution boards shall be factory assembled.

Distribution boards shall be of a dead-front safety type, equipped with protective devices as shown on the Schedules.

Distribution boards shall have 380 V volt duty rating, with other ratings as shown on the Drawings.

Distribution boards circuit numbering shall be such that, starting at the top, odd number shall be used in sequence down the left-hand side and even numbers shall be used in sequence down the right-hand side.

Distribution boards shall conform to BSEN 60439-1:1994 and EN 60898.

Distribution boards shall incorporate plug-in type miniature circuit breakers of tripping characteristics B, C or D for lighting, miscellaneous power or motor loads as necessary complete as specified and as shown on the drawings and to the approval of Engineer.

Main breakers of all main breaker type distribution boards shall be plug in type miniature circuit breaker or bolt-on molded case type circuit breaker as shown on the drawings.

E-8B Cabinets and Fronts:

The distribution board bus assembly shall be enclosed in a galvanized sheet steel cabinet. Cabinet shall be of sufficient size to provide a minimum gutter space of 10 cm on all sides. The thickness of the sheet steel shall be minimum 1.5 mm.

Fronts shall include doors and have flush, brushed stainless steel cylinder tumbler-type locks with catches and spring loaded door pulls. The flush lock shall not protrude beyond the front of the door. All distribution board locks shall be keyed alike. Fronts shall have adjustable indicating trim clamps which shall be completely concealed when the doors are closed. Fronts shall have approved directories with name of panel, number of phases, wires and voltage written on them.

Doors shall be mounted by completely concealed steel hinges. Fronts shall not be removable with door in the locked position.

Fronts shall be of code gauge, full finished steel with rust-inhibiting primer and baked enamel finish. Color shall be gray to ANSI No. 61, BS 381 C or approved equal.

Joints shall be welded, galvanized and reinforced where necessary and galvanized after fabrication.

E-8C Distribution Board Bus Assembly:

Bus for connections to the branch circuit breakers shall be the "Distributed Phase" or "Phase Sequence" Type.

Three-phase, four-wire bussing shall be such that any three adjacent single-pole breakers are individually connected to each of the three different phases in such a manner that two or three pole
breakers can be installed at any location. All current carrying parts of the bus assembly shall be plated.

Main and neutral buses shall be minimum 98 percent purity, rectangular copper bars, provided with bolted-type lugs as necessary.

Buses of miniature circuit breaker distribution boards shall be suitably braced for a minimum short circuit duty equal to 6,000 Amps Or more unless otherwise indicated.

Buses shall be rigidly supported and insulated and be so designed that branch circuits can be removed without disturbing adjacent units or changed without additional machining, drilling or tapping.

Necessary bussing, drilling and blank plates shall be provided for installation of future circuits when so indicated in the Schedules on the Drawings.

All screws and bolts used for making copper connections shall be equipped with lock washers. Riveted connections will not be acceptable.

Mains shall be equipped with solder less pressure indent type connectors and have means to prevent swiveling of connector.

Neutral terminal strip shall be full size and shall incorporate one neutral terminal for each single pole and neutral way.

Aluminum shall not be used for any parts of the distribution board.

Back pan or mounting on which buses and branches are mounted shall be rigid to properly support the component parts.

Reinforcing of back pan shall be by flanging or addition of angle iron.

Buses, connectors, and terminals shall be silver plated to a minimum thickness of 0.1 mm.

**E-8D Split Bus Distribution Boards:**

Split bus distribution board shall incorporate a main switch or circuit breaker for the entire distribution board and two or more sub-main earth leakage circuit breakers that shall protect each section of the distribution board circuits against earth leakage.

For the wiring of circuits consisting of wire sizes 10 mm2 and larger shall be of the bolted pressure type with a pre insulated sleeve.

Connectors shall be manufactured from high conductivity copper, electro tin-plated.

**E-8E Earthing:**

An acceptable terminal bar for equipment earthing conductors shall be provided with a minimum number of cable terminations equal to the single pole number of ways of the distribution board.

A cable connection shall be made from the earth bar to the cable gland of the incoming feeder as applicable.

Cabinet shall be provided with an earth connector welded to it.
E-8F Circuit Breakers:

All plug-in type circuit breakers shall have trip settings, and number of poles, as indicated on the Drawings. All circuit breakers shall have their ampere trip rating clearly marked and visible.

Breakers shall have quick-make, quick-break, toggle mechanism and shall provide positive trip-free operation on abnormal overloads. Stationary and movable contacts shall be adequately protected with effective and rapid arc interruption. Each pole of the breaker shall be equipped with an inverse time delay thermal over current trip element and magnetic instantaneous over current trip elements for common tripping of all poles for multiple breakers. Multiple pole breakers shall have a single handle mechanism. Automatic tripping shall be indicated by the breaker handle assuming a clearly distinctive position from the manual ON and OFF position.

Miniature circuit breakers shall provide tripping characteristics in accordance with EN 60898 in an ambient temperature of 40 deg. C. in accordance with the latest amendment.

Circuit breakers shall have minimum RMS symmetrical interrupting capacities equal to 6,000 Amps or more at 380 V for miniature circuit breakers and capacities equal to the values indicated in the drawings for molded case circuit breakers but shall be in no case less than the bus bar short circuit bracing of the distribution board.

Molded case circuit breakers shall have frame sizes equal to or greater than their trip ratings unless otherwise indicated and shall be suitable for operation at an ambient temperature of 50 degree C.

E-8G Earth Leakage Circuit Breakers:

Each leakage circuit breakers shall be current operated type providing protection against overloads, short circuit, and low level earth faults of 30mA or 300mA as applicable or as shown on the drawings.

It shall fit in standard distribution boards.

A push-to-test mechanism shall be provided to ensure proper operation.

Enclosure shall be glass reinforced.

Breaker shall have 6000A interrupting capacity unless otherwise indicated.

Breaker shall otherwise be similar to miniature circuit breakers.

E-8H Distribution Board Installation:

Distribution board shall be aligned, leveled and securely fastened to the building surface mounted application or recessed in the wall flush mounted distribution board.

Connecting conduits shall not be used to support the distribution board.

All unused openings in distribution board cabinets shall be properly closed.

Distribution board interiors shall not be installed in cabinets until all conduit connections to the cabinet have been completed.

Trim for flush mounted cabinets shall be installed in plaster frame, flush with finished wall.

Trim shall be installed plumb and square to finish painting.

Concealed surfaces of cabinets shall be given on site a heavy application of emulsified asphalt prior to installation.
E-8I Shop Drawings:

The Contractor shall submit shop drawings for the switchboards including schematic diagrams with all protective devices, control, instruments and instrument transformers details, dimensions of the assembly, etc. A copy of these shop drawings shall also be submitted to the local power authorities for approval. Any modification required by the Engineer or the local power authorities to allow the equipment to comply with the codes, standards and specifications called of hereinbefore shall be carried out without additional charges.

E-8J Applicable Standards:

1. Requirements for type tested or partially type tested assemblies
   - BSEN 60439-1 1994
   - EN 60898

2. Specification for Color identification

End of Sub-Section (E-8)
E-9A General:
The contractor shall supply, install and connect a complete Power Factor Correction Capacitor system with control equipment for automatically controlling the connection and disconnection of capacitances in response to changes in the load power factor. The system shall be free standing individual unit or part of the switchboard as indicated on the Drawings. The system shall provide a complete automatic regulation of the connected capacitor power at peak and off peak times.

The system shall be fully assembled and internally connected. All equipment shall be suitable for continuous operation within the specified ambient conditions.

The capacitor banks shall comprise one cubicle for protection and control equipment and steel racks for the capacitor units. A discharge resistor shall be fitted in the terminal box of each capacitor unit.

The set of equipment for one capacitor 'step' shall comprise one triple pole contactor and a three phase fuse unit with fuses.

The cubicle shall contain bus bars for the main supply cable, terminal blocks for leads for the current transformer, control lead fuses. A reactive power regulator, together with capacitor step indicator lamps shall be mounted on the door of the cubicle. A shunt connected harmonic filter shall be included in the capacitor bank assembly.

The equipment ratings shall be selected to give a generous margin to withstand the high capacitor currents due to harmonics on the system voltage.

The equipment shall comply with BSEN 55014:1993 with respect to electro- magnetic radio interference.

E-9B Power Factor Correction Capacitors:
Capacitors shall be of proven and established design. Capacitors shall conform to IEC-831-1,2 and amendment 2.

Capacitor elements shall comprise a winding of metal zed film dielectric and incorporate an internal fuse link, all resin encapsulated and mounted in plastic container. All capacitors shall be self healing type.

Capacitors shall be low loss type. Losses shall be less than 0.5 watts per KVAR.

Capacitors shall have a dielectric voltage rating of 380V 3 phase, 50 HZ.

Capacitor units shall comprise of a sheet steel enclosure incorporating a number of capacitor elements. The enclosure shall be filled with granules or suitable proven alternative to absorb the energy of any major element failure.

Every capacitor shall be capable of operating for prolonged periods, without damage, at voltage 10 percent higher than the rated voltage.

All capacitors shall be capable of operating without damage under conditions in which the current through it has an r.m.s. value exceeding by 15 percent the current corresponding to the rated (sinusoidal) voltage and frequency.

Each capacitor shall be labeled to warn of possible voltage damages.

E-9C Protection:
The capacitor system shall be equipped with dust-tight, hose-proof terminal boxes, to IP55.

The surface treatment of the capacitor units and the cubicles shall be suitable for outdoor installation. The sheet-metal surface shall be treated with primer and finished in two-component baked enamel.

The control equipment cubicle shall be provided with ventilation openings if used in door only. Each cubicle and all of the equipment within it shall be so arranged that every item of apparatus is readily accessible of adjustment, where this may be necessary and for maintenance.

**E-9D Power Factor Regulator:**

The power factor regulator shall be microprocessor based and shall be programmable at site. The Power Factor Regulator programmer shall permit different switching circuits depending upon the targeted phase angle. Regulator operation shall be insensitive to harmonics and shall have an automatic no-volt release suitable for operation in temperature up to 70 deg. C.

The power factor regulator shall have "AUTOMATIC" or "MANUAL" control facility. The desired power factor shall be adjustable from 0.9 capacitive to 0.7 inductive. Capacitor switching time shall be adjustable from 1 to 99 seconds.

The regulator shall be flush mounted in the cubicle door and shall have built in digital power factor meter and fault indicator. LED indications shall be provided to indicate Number of steps switched on, Capacitive or Inductive load. The power factor regulator shall have means to adapt itself to network phase rotation and reversal of current transformer terminals.

**E-9E Principle of Operation:**

The power factor regulator shall continuously sense (The reactive power) of the circuit being considered for power factor correction. If the computed power factor differs from the targeted factor for more than 10 seconds, the regulator shall switch a contactor to switch into or out of the circuit. Contactors shall be opened or closed as required to bring the circuit power factor closer to the targeted one. Only one capacitor shall be switched at a time.

**E-9F Contactors:**

Contactors used in capacitor bank circuits shall be suitable for capacitor switching duty and shall withstand large transient current peaks at high frequency. The contactors shall have a life time of minimum 100,000 operations under capacitor switching conditions. Contactors shall be rated for 1.5 times the normal rated current of the capacitors. The contactors shall conform to IEC 947-4-1.

**E-9G Fuses:**

Three phase high rupture capacity fuses shall be provided for each capacitor step. Fuses shall be modern industrial design, current limiting type with a breaking capacity exceeding 100 KA. Fuses shall be confirm to the requirement of IEC 269.

The utilization category of the fuses shall be gG. They shall be plug-in type with proper fuse handle to ensure the safety of operating personnel.

**E-9H Applicable Standards:**

Radio frequency interference suppression as BSEN 55014:1993.

*End of Sub-Section (E-9)*
E-10A General:

The Contractor shall, unless otherwise indicated on the Drawings or Bills of Quantities, supply, install and connect the lighting fixtures including but not limited to lamps, ballasts, accessories, fixing hardware necessary for installations, as shown on the Drawings, as required, and as herein specified.

Fixture, housing, frame or canopy, shall provide a suitable cover for fixture outlet box or fixture opening.

Fixtures shall not cause a temperature exceeding 90 degree centigrade on any outside surface.

Fixtures shall comply with all applicable requirements as herein outlined unless otherwise specified or shown on the Drawings.

The Contractor shall be responsible to supply the specified lighting fixtures as indicated on the drawings.

Technically equivalent and architecturally acceptable lighting fixtures may be accepted with proper price justification and to the decision of Engineer.

Fixtures shall bear manufacturer's name and the factory inspection label.

Fixtures shall be completely wired and constructed to comply with IEC Publication 598-1 598-2 and BSEN 60598-1: 1993 unless otherwise specified.

All luminaries supplied by the contractor shall be photo-metrically tested to BS 5225: Part 1.

Re-lamping the fixture shall be possible without having to remove the fixture from its place.

Certain fixtures may be shown in provisional position. They shall be exactly located as soon as the final layout of equipment is known.

Any plastics used in the luminaries shall be light and U.V. stable and shall be suitable for their application.

All sheet steel components shall be suitably pre-treated and electro-statically spray-painted using acrylic polyester or epoxy powder paint.

Fixtures that are used under canopy or directly exposed to weather shall be considered as being outdoor type.

E-10B Construction - General:

Indoor fixtures shall be constructed of 0.7 mm thick steel minimum. If other metals are used they shall be of the required thickness to have at least the same mechanical strength.

Cast portions of fixtures shall be not less than 1.5 mm thick.

Metal parts of the fixtures shall be completely free from burrs and tool marks. Solder shall not be used as a mechanical fastening device on any part of the fixture.

Fixtures with visible frame shall have concealed hinges and catches.
Recessed fixture shall be constructed so as to fit into ceiling without distorting either the fixture or the ceiling. Plaster rings shall be provided for plaster ceilings. The Contractor shall coordinate the dimensions with the false ceiling tile or panel dimensions.

Outdoor fixtures (under canopy or directly exposed to the weather) shall be constructed of an appropriate weather resistant material including gaskets to prevent entrance of water into wiring.

External fixtures shall be constructed to minimum classification of IP44 and be class unless otherwise stated.

Fixtures with hinged diffuser doors shall be provided with spring clips or other retaining devices to prevent the diffuser from moving.

Bathroom fixtures shall be marked as being suitable for damp locations and shall be of minimum IP44 degree of protection, class-1. Lamp-holders of such fixtures shall be provided with a protective shield to prevent contact with the lamp cap.

Fixtures with exposed metal parts shall be provided with a means for connecting an equipment earthing conductor for such fixtures.

Incandescent fixtures shall be equipped with porcelain medium base with nickel-plated shells. Sockets shall be bayonet type for lamps up to and including 150 watts and right hand screw type for lamps 200 watts and above.

Lighting fixtures intended for use as emergency lighting either as self contained or slave type shall be “F” marked when used in or on ceilings consisting of flammable material.

Pendent fixtures and lamp-holders shall be provided with ball type aligners.

E-10C Construction - Fluorescent Fixtures:

Fixtures shall be provided with white click-in type lamp-holders.

Pendent individually mounted fixtures 60 cm and longer shall be provided with twin stem hangers. Stems shall have ball aligners and provision for a minimum of 2.5 cm vertical adjustment.

Diffusers shall be manufactured from one piece non-glued methacrylate.

Mirror system light controlled fixtures shall comprise a metal encased aluminum mirror system with aluminum mirror strips forming a parabolic reflector. Lamps shall be screened in the longitudinal direction by means of matt-white louver partitions unless otherwise specified on the drawings.

Clear smooth diffusers shall be smooth from outside, finely grained from inside.

Corrosion resistant fixtures shall comprise polyester resin fiber-glass reinforced body, dust and splash-proof. Damp-resistant fixtures shall comprise polyester resin fiber-glass reinforced body, dust and jet-proof.

Luminaries containing compact fluorescent lamps shall be designed to ensure the correct working conditions for the lamp.

All compact fluorescent luminaries shall, unless otherwise stated, be supplied with low loss control gear and single pulse electronic starters.

Explosion proof fixtures if any shall be suitable for hazardous location especially for paint spray booths, and locations having deposits of readily combustible paint residue. All exposed hardware shall be stainless steel. All exterior material shall be non-sparking.
E-10D Finish:

All hardware shall be bonder zed, cadmium-plated, given a corrosion-resistant phosphate treatment or other approved rust inhibiting prime coat, to provide a rustproof base before application of finish.

Finish shall be baked enamel.

Non-reflecting surfaces such as fixture frames and trims shall be finished with baked enamel paint, unless otherwise specified. The color of the paint shall be as indicated on the Drawings or as directed later by the Engineer on Site.

Light reflecting surfaces shall be finished with baked white enamel paint having a reflection factor of not less than 85 %.

All parts of the reflector shall be completely covered by the finish and free from irregularities.

Unpainted surfaces shall be finished with a clear lacquer except for anodized or “Azac” surfaces.

After finish has been applied and cured, it shall be capable of withstanding a 1 cm radius bend without showing signs of cracking, peeling or loosening from the base metal.

Finish shall be capable of withstanding 72 hours exposure to an ultra-violet RS sun lamp placed 10 cm from the surface without discoloration, hardening, or warping and shall retain the same reflection characteristics after exposure.

E-10E Wiring:

Wiring within fixture and for connection to the branch circuit wiring up to the outlet box of lighting point shall not be less than 1.5 mm². Insulation shall be silicone rubber, finish shall be glass braid. Suitable for 150 degree centigrade normal service temperature, 300/300 volts. Cable entry to fixture shall be dust sealed.

E-10F Installation:

Fixtures shall be installed at mounting heights as detailed on the Drawings or as instructed on Site by the Engineer.

Fixtures and/or fixture outlet boxes shall be provided with hangers to adequately support the complete weight of the fixture. Design of hangers and method of fastening, other than shown on the Drawings or, herein specified, shall be submitted to the Engineer for approval.

Pendent fixtures within the same room or area shall be installed plumb and at a uniform height from the finished floor. Adjustment of height shall be made during installation.

Flush mounted recessed fixtures shall be installed so as to completely eliminate leakage of light within fixture and between the fixture and adjacent finished surface.

Fixtures mounted on outlet boxes shall be rigidly secured to outlet box. Hickeys or extension pieces shall be installed where required to facilitate proper installation.

Surface mounted fixtures longer than 60 cm shall have one additional point of support besides the outlet box fixture stud when installed individually.

Fixtures located on the exterior of the building shall be installed with non-ferrous metal screws finished to match the fixtures. Where Edison screw lamp-holders are used, the outer contact must be connected to the neutral conductor.
Fixtures installed in false ceiling shall be connected to the relevant lighting outlet through a flexible cord & ceiling rose, unless otherwise specified under “CONDUITS”. Each fixture shall have its corresponding lighting outlet.

**E-10G Lamps - General:**

Lamps shall be supplied and installed in all lighting fixtures listed in the Schedule of Lighting Fixtures on the Drawings.

Lamps used for temporary lighting services shall not be used in the final lamping of fixture units. Lamps shall be of wattage and type as shown in the Schedule of Lighting Fixtures.

Lamps for permanent installation shall not be placed in the fixtures, until so directed by the Engineer and this shall be accomplished directly before the building areas are ready for occupancy by the Employer.

**E-10H Lamps - Fluorescent:**

Lamps shall be of the normal start energy saving type, unless otherwise indicated.

Lamps shall be krypton filled, in place of the traditional argon fill.

Lamps shall have bi-pin bases and a minimum approximate rated life of 8,000 hours.

Lamps with WHITE color rendering shall have the color rendering features similar to TL'D color 84 at 4000K and lamps with WHITE DELUXE color rendering shall have the color rendering features of TL'D color 83 at 3000 K as manufactured by Philips (Holland). Lamps shall have 96 lm / watt output minimum based on 36 watt lamps.

Compact fluorescent lamps shall be of the 4-pin type manufactured in accordance with BS 6982.

Compact fluorescent lamps shall be suitable for operating as emergency lighting sources where specified.

Compact fluorescent lamps shall be suitable for operating on standard wire wound and H.F. ballasts.

Where the lamps are used horizontally, they shall be adequately supported along their length.

Lamps shall have WHITE color rendering unless otherwise indicated.

**E-10I Lamps - Incandescent:**

Incandescent lamps shall be inside frosted type, unless otherwise indicated.

Lamps shall have a minimum approximate rated life of 750 hours. Lamps shall have medium base bayonet type for lamps up to 150 watts and right hand screw type for lamps 200 watts and above unless otherwise indicated or approved.

Lamps shall be manufactured by Philips (Holland) or approved equal.

**E-10J Lamps - Halogen:**

Halogen lamps shall be either mains-voltage or low voltage type as described in the lighting fixtures schedules in the drawings.

The tubular envelope of the lamp which is made of a special quartz glass shall be resistant to the high temperatures needed for the halogen cycle to function.
Care shall be taken in handling the quartz envelope lamps, where the lamp should not be handled directly.

The lamp shall be cleaned using soft cloth moistened with white spirits.

Luminaries using low voltage tungsten-halogen lamps shall be supplied complete with its own transformers unless otherwise stated. Wire wound transformers shall be rated at 250/11.8 volts and shall comply with IEC742, class I/class II and be insulated to class H of BS 2757.

Transformers shall be protected against overload and short circuiting.

Final connections to luminaries shall be carried out using silicon rubber sheathed cables.

Dimmers for low voltage tungsten-halogen lamps shall be hard wired type suitable for inductive loads.

Transformers used in dimmed circuits shall be down rated as recommended by the manufacturer.

Electronic transformers shall be protected against short circuit and overload. It shall contain a soft start circuit and be self regulating.

Electronic transformers shall comply with IEC 742 and 34C/comex (PK) 8 and 14 with RFI suppression complying with BSEN 55014:1993.

Electronic transformers used in dimmed circuits shall be suitable for dimming. The dimmer shall be compatible with the transformer. When installed in ceiling voids, the transformer shall be capable of subsequent removal either through the fitting aperture or through an access panel.

Lamp holders in dichroic or capsule luminaries shall be easily accessible for re-lamping.

Where sealed low voltage lamps are used the luminaries shall be designed to cope with the increased temperature.

The integral wiring of dichroic lamps shall cope with the increased temperature.

All dichroic lamps shall be of the captive type.

Capsule low voltage lamps shall not be installed using bare hands. Protective glass shall be incorporated in capsule lamps fittings.

Mains voltage tungsten halogen lamps shall be either of the single ended or double ended type as specified in the fixtures schedule. The single-ended lamps shall be of the frosted version unless otherwise specified or directed by the Engineer.

Double envelope and reflector lamps could also be implemented if specified or directed on site.

The design of main voltage luminaries shall insure the withstanding of bulb wall temperature of 250 degree C and a maximum pinch point temperature of 350 degree C.

**E-10K Ballasts - Fluorescent:**

Only single and/or two-lamp ballast shall be used in any one fixture.

Ballasts shall be low loss high power factor type, with a minimum power factor of 0.9. Voltage rating shall be equal to the nominal voltage or be the next higher standard.

Ballasts sound performance shall be suitable for the lowest sound level likely to be encountered in the subjected space with sound ratings as shown on the Lighting Fixtures Schedules of the Drawings.
Ballasts shall have manufacturer’s lowest sound level and case temperature rise rating.

Ballasts shall be special cool operated type.

Ballasts shall be rapid start type unless otherwise indicated.

**E-10L Starters - Fluorescent:**

Starters shall produce a sufficiently high peak voltage for proper ignition of the lamp. Ample re-heating of the lamp electrodes prior to ignition shall be provided to have a favorable effect on the life of the lamp with a minimum of end blackening.

The glow-switch and a radio-interference suppression capacitor shall be safely housed in a high quality white polycarbonate canister ensuring excellent insulation.

Starters shall comply with IEC 155/155A or approved equal.

**E-10M Starters - Fluorescent (Electronic):**

Starters shall be electronic type, enclosed in a polycarbonate box mounted inside the luminaire with the ballast.

Electronic starters shall comply with BS 3772 Part 1.

Starters shall have negligible watt loss, and shall be noiseless.

It shall be similar to the universal viva tronic catalogue ref. G69577 as manufactured by Thorn EMI Lighting, ES 08 as manufactured by Philips or approved equal.

**E-10N Ballasts - Fluorescent (Electronic):**

Ballast shall be solid state electronic controlled type with no noise nuisance, high operating frequency, 0.95 power factor, instant non-flickering start, automatic switch-off if lamp is defective, no stroboscopic effect and no electrode flickering. All components shall be mounted on a common wiring board, with sheet metal housing for mechanical protection. It shall require no starter.

Earth leakage current must be below 0.3 mA measured according to IEC-598-1.

Radio frequency interference must be in accordance with EN 55015.

Ballast must be in accordance with IEC 928 (ballast safety) and IEC 929 (ballast performance).

Total harmonic distortion must be below 10% and in accordance with EN 6000-3-2.

**E-100 Capacitors:**

Power factor correction capacitors shall be metal foil dry type impregnated paper, metalized film or polypropylene film, encased in an insulated aluminum canister. Capacitors shall be rated at 250V, 50/60 Hz and BS EN 61049:1993. They shall be rated 800 volt, 50/60Hz.

Radio interference suppression capacitors shall be dry type ceramic or equivalent complying with BS EN 61048:1993 7. They shall be rated at 800 volts, 50/60 Hz.
E-10P Fixture Samples:

Detailed catalogue cuts for all fixtures or, if so required by the Engineer, sample fixtures shall be submitted for prior approval of the Engineer before orders for the fixtures are placed.

E-10Q Applicable Standards:

2. Specifications for Lighting Fixtures Photometric - BS 5225 (1985)

End of Sub-Section (E-10)
E-11A General:
The contractor shall supply and install the fire alarm and emergency communication system as herein specified and as shown on the drawings. The system shall be of the Microprocessor-based Intelligent Analogue Addressable type with continuous monitoring of analogue quantities and automatic adjustment of alarm threshold.

The system and installation of the system shall be in accordance with (NFPA standard and CL requirements) OR in accordance with (BSEN54 standard and LPCB approved) and the latest requirements laid by Local Civil Defense authorities.

All equipment used in the system shall, as far as practicable, be designed and provided by single manufacturer, and shall be compatible with relevant sections of the overall security systems.

The Fire alarm control panel shall have minimum ingress protection of NEMA 1 or IP 30 and shall be suitable for recessed mounting at locations indicated on the drawings.

E-11B Terminology and Definitions:
Unless otherwise specified, the definitions and terms used in this specification shall be in accordance with NFPA72, NFPA 101, CL 864, CL 1481 and other UL related parts and the documents referred in these standards. In addition, the following definitions shall apply:

1. **Fire Routine**
The action to be carried out on incidence of a fire alarm, which have been agreed with the Local Fire Authorities. This includes the method of operation of the fire alarm system, including the system responses and stags and interaction with other related systems.

2. **Analogue /Address able System**
Each detector in addition to being addressable outputs a digitally encoded “Analogue” signal which varies in the short-term’ due to fault and alarm conditions and in the long-term due to environmental soiling.

E-11C Environment:
Unless otherwise specified, all equipment used in the system shall be suitable for continuous operation in the following ambient conditions:

- **Temperature:** 0 to + 0 to 49 0C
- **Relative humidity:** 0% to 0% to 93 % RH non-condensing
- **Barometric pressure:** 86 K 86 kpa to 106 Kpa

E-11D System Features:
- The system shall consist of equipment provided for receiving end indicating all signals initiated from the associated services or manual cal points and activating alarm sounders and signaling devices.
- Control panels shall be of modular design with plug in modules. Each module shall operate independently of other modules. The operation of control panel in fault or alarm conditions shall be assisted by guided instructions with visual indicators on the control buttons.
- The system shall be fully integrated with an Emergency Communication system (Voice Evacuation and Fire Telephone). The fire alarm and communication system shall be manufactured by single manufacturer.
- System response to any alarm condition must occur within 3 seconds, regardless of the size and the complexity of the installed system.
- The system shall have the facility to display at the off-normal condition at group or all panels in the network and control the entire system from any panel in the network. The system which can route the Common Control Functions to any node of the system as a function of the time of day and date is preferable.
- The system shall be capable of future expansion without obsoleting any of the original equipment.
- Facility for testing the sensors and manual cal points of any zone, without affecting the function of other zones of the system shall be available.
- The system shall have the Pre alarm and alarm verification facility. Both functions to be set for each individual smoke detector in the system to minimize false alarms.
- Local audible alarm at the control panel shall distinct for fire detection alarms and system fault conditions.
- It shall be possible to over-ride delayed alarm signals to the Local Civil Defense Authorities by call points designated for evacuation purposes.
- Dedicated telephone lines for transmission of emergency calls shall not be used for any other purpose.

**E-11E Microprocessor System**
- The system shall be of the True Distributed Intelligence including microprocessor-based Detectors and Modules.
- Electronic Addressing of Field Devices shall be provided.
- The Fire Alarm System shall provide 3 redundancy levels as follows (Network Level, Panel Level and Field Device Level)
- All input signals received by the central control system from the outstations shall be automatically processed and presented to the operator by means of main fire alarm display.
- All System operational software is to be stored in FLASH memory. Control Panel disassembly, and replacement of electronic components of any kind shall not be required in order to upgrade the operations of the installed system to conform to future application code and operating system changes.
- The system shall be continuously self-monitoring type. Any faults and malfunctions in the system shall be displayed.
- Ability to download all system applications programs and “firmware” from a computer through a single point in the system.
- The capacity of data processing system shall include 25 percent spare capacity for future use.
- Data processing system shall perform for all major tasks and shall have a supervisory system to raise a visual and audible fault if the processor fails.

**E-11F Communication Network**
- The system shall be of Multi - Priority, token passing, peer-to-peer network wired as Class A (Style 7).
- The communication network between the panels shall operate with the specified wiring system. Communications faults shall be announced at all panels. Transmission errors shall be indicated at all panels in the network.
- A loop type network shall be provided by connecting each panel in series starting from and ending at the same panel. It shall be possible to expand the network in the future without affecting the existing system.
- Any defective device in the detection loop shall be automatically bypassed without affecting the normal function of the rest of the system.

**E-11G Zoning**
- The fire alarm and detection system shall be divided into zones to comply with NFPA or BSEN54.
- A fault in any one zone shall not interrupt the operation of other zones.
- The system zoning shall be definable within the system program to allow the quick identification of the alarm zone and testing of the installed system based on the physical layout of the system and not on the wiring of the field circuits connected to the Fire Alarm Control Panel.
- Each Fire Alarm zone shall be separated from other zones in the same loop by an on line short circuit isolator.

E-11H General Indication and Display:
- General display shall incorporate an assigned area for zone indication with LED indicator for each zone arranged in accordance with manufacturers standard design.
- A display diagram shall be provided. The diagram shall include a representation of the building(s) with a clear display of all areas covered by the fire alarm system including the details of building entrances; circulation areas escape routes, and the division of zones.
- Display diagram shall be permanently and clearly labeled by engraved labels. Self-illuminating switches may be permanently labeled by engraving or printing inside the lens. Al lettering shall be in capital letters.

E-11I Initiating Detectors:
- The automatic fire alarm detectors and modules shall be soft addressable intelligent analog addressable devices with built - in microprocessor. Systems which produce electrical as built mapping to reduce maintenance time and coast is preferable.
- The automatic fire detectors shall be fixed to the installation by mean or plug-in bases.
- The base shall incorporate the optional feature of being able to lock the detectors in place once plugged in.
- The alarm response time for all intelligent initiating detectors shall be less than 1 second.
- The detector’s bases must not incorporate any of the circuitry required for communicating detector statuses to the fire alarm control panel.
- The intelligent smoke detector shall have the Pre alarm and alarm verification facility to reduce false alarm.
- The system detectors shall be available in multi-sensor (ion, photo, and heat) if required.

E-11J Alarm Signals:
- The system shall provide fully monitored output lines to activate audible alarm signal.
- The response time for giving general alarm shall be in accordance with NFPA or BSEN54.
- Alarm signals shall not be routed through private exchange or any other equipment vulnerable to fire Transmission of alarm signals shall be fully automatic, once initiated.
- Faults in sounder circuits shall effect not more than 50 percent of sounders in each alarm zone.
- The sound levels of fault warning sounder shall be at least 5 dBA above the average ambient sound level in that area. Sound level of fault warning sounders at operator location shall be minimum 70 dB(A).
- The sound levels of alarm sounder shall be at least 75 dBA at 3 meter but not more than 120 dBA. To ensure that public mode signal are clearly heard, they shall have a sound level of at least 15 dBA above the average ambient sound level in that area.
- The indicating circuit used in high noise area’s, as mechanical rooms shall be combined horn and strobe units.
- Sounders shall be installed /wired in detector loops or on separate sounder circuits, as per the approved manufacturers standard.

E-11K Voice Evacuation System:
- The Fire Alarm / Life Safety System shall incorporate a true digital integrated audio system into the network, multiplexing two independent audio channels. The system shall include Distributed amplifiers for speaker circuits.
- The voice evacuation system shall have the capability to be used as a public address system (if required) to broadcast a background music in lift lobby areas in normal operation mode.
- The system shall be capable of selecting the proper tones and phrases based upon specific conditions and location, sort and transmit the audible information and repeat the transmission as many times as required.
- The system shall have the ability to generate pre-programmed digitized phrases, words, and alarm tones to all or specific areas of the building. The message contained in the fully digitized message unit shall have the facility to be edited and modified or even recorded in the field via a normal computer.
One-way communications of announcements and messages originating at the control Room shall be via speakers located throughout the building.

The system shall have the ability to automatically or manually sound the evacuation tone on the floor of alarm, while at the same time being able to sound the first stage alert tone or voice instructions to other areas of the building.

The master control panel located in the control Room shall include the master microphone, master telephone handset, and the following indicators, switches and components:

1. One Switch/LED for each speaker circuit zone to allow emergency voice communication selection for Evac, Alert, and Paging.
2. Switches for speaker “Al Cal”, “Page TO Evac”, “Page to Alert”, “Al Cal Minus”.
3. One flashing amber LED for each speaker zone to indicate a trouble condition on either of the speaker circuits in that zone.
4. One red LED for each speaker zone to indicate when that zone is in Evacuation mode.
5. One amber LED for each speaker zone to indicate when that zone is in the Alert mode.
6. One Green LED for each speaker zone to indicate when that zone is in paging mode.
7. One switch for general evacuation alarm for each floor.
8. One switch for general Paging for each floor.
9. The Microphones shall be a push-to-talk, dynamic noise canceling type with a frequency response from 200 to 4,000 HZ. Any automatic alarm, which has been in operation, shall be overridden by the use of the microphone. When the manual voice announcements are completed the system shall revert back to the previous alarm unless reset or restored to normal by authorities in charge.

E-11L Fire Telephone System:

A telephone control system shall be housed in the master fire control panel in the control room. The Fire Fighters’ Telephone System shall include an 8-line LCD to show the operator the identity and location of up to 20 waiting cal s. The LCD will display cal in information in full language, without the need for individual LED’s and switches per telephone station. The user shall connect a cal by pressing the ‘connect’ switch.

Systems require individual Switch/LED to establish communication with remote fire telephone may be acceptable subject to engineer approval.

The telephone circuits shall be annunciated and cause an audible alarm whenever a cal is placed to the control center from a remote telephone location.

The master telephone control module shall provide processing of all two-way communication functions. This module shall include a sonalert for cal and trouble signalling, trouble silence switch with ring back, a trouble indication and supervising monitor circuit.

A Red master telephone handset with flexible-coiled 5-foot cord shall be provided and recessed within protective enclosure at the Main Control Panel.

The system shall be capable of handling single or simultaneous conversations with as many as five phones connected. The phone system circuits shall be designed for clear, intelligible two-way conversion between all phones of the system.

Provide one circuit per each remote fire tel.

E-11M Electromagnetic Interference:
The fire alarm end detection system shall be equipped to comply with NEC 760 or BS 800 and BS 6667, in respect to the limits of electromagnetic interference. System Components

E-11N Fire Alarm Control Panel:
The Control Panels (CP’s) shall be the central processing unit of the system, receiving and analyzing signals from fire detection initiating devices. Providing audible and visual information to the user, initiating automatic alarm response sequences and providing the means by which the user interacts with the system.

All CP’s shall have the following minimum standard requirements:

- UL listed or LPCB approved
- Multi-Priority, token passing, peer-to-peer network connection of up to 64 system nodes wired as <Class A (Style 7)> <Class B (Style 4)>. 
• “Power supply and charger
• “Battery supervision.
• “Tree Distributed Intelligence, including microprocessor-based Detectors and Modules.
• “Removable, Interlocked terminal blocks for the connection of the field wiring to the Fire Alarm Control Panel.
• Advanced Power Management
• Dead Front Construction.
• “Standardized software
• “Fully field programmable and editable
• “Operator Features which may include but not limited to the followings:
  - Control keys
  - Function keys
  - Acknowledge keys
  - Display action keys
  - Entry key
  - Character alphanumeric liquid crystal display
  - Alarm supervisory and trouble LED indication
  - Power on indicator
  - Common Alarm indicator
  - Common Fault indicator
  - CPU Fail
  - Disable, Isolate

The control keys shall be programmable; they may used for manual activation of A/C shut down etc.
The ‘Function Keys’ Display Action Keypad and the Entry Keypad shall be user friendly. Operations shall include Enabling and Disabling circuits, turn control points on or off, set time and date. Display historical logs etc.

The acknowledge key pad shall have the following functions:
  - Alarm Acknowledge
  - Supervisory Acknowledge
  - Trouble Acknowledge
  - Alarm Silence
  - System Reset

E-110 Ionization Smoke Detector, Sensors:
Ionization smoke sensors shall be of the analogue addressable type and shall be capable or detecting visible and invisible combustion gases emanating from fire. Ionization smoke sensors shall comply with UL 268 or BS 5445: part 7.

The ionization smoke sensors shall use dual ionization chamber in which the air is ionized by a single radioactive source. The detector shall have high resistance to contamination and corrosion.

The electronic assembly of ionization smoke sensors shall be encapsulated using a high resistively epoxy resin. The ionization sensors shall include RFI screening and feed-through connecting components to minimize the effect of radiated and conducted electrical interference.

The ionization smoke sensors shall incorporate an LED clearly visible from outside, to provide indication of alarm actuation

E-11P Optical Smoke Sensor:
The optical smoke Sensors shall be of the analogue addressable type and shall be capable of detecting visible combustion gases from fires. Optical smoke Sensors shall comply with CL268 or BS 5445: part 7.
The optical smoke Sensors shall employ the forward light-scatter principle using optical components. The design of optical smoke Sensors sensing chamber shall be optimized to minimize the effect of dust deposits over a period of time. The sensors shall incorporate screens to prevent all but the very small insects entering the sensing chamber. The optical smoke Sensors shall have high resistance to contamination and corrosion.
The electronic assembly of optical Sensors shall be encapsulated in high resistively epoxy resin. The optical smoke Sensors shall incorporate an LED clearly visible from the outside, to provide indication of alarm actuation.

**E-11Q Optical I Heat Smoke Sensor :**
Provide intelligent multi-sensor smoke detectors. The multi-sensor analog detector shall use a light scattering type photoelectric smoke sensor and a fixed temperature- type heat sensor to sense changes in air samples from its surroundings.

The integral microprocessor shall employ time based algorithms to dynamically examine values from both sensors simultaneously and initiate an alarm based on that data. The detector shall continually monitor any changes in sensitivity due to the environmental affects of dirt, smoke, temperature, aging and humidity. The information shall be stored in the integral processor and transferred to the analog loop controller for retrieval using a laptop PC or Program/Service Tool.

The 3D Multi-sensor detector shall be rated for ceiling installation at a minimum of 30 ft (9.1 m) centers and be suitable for wall mount applications. The 3D Multi-sensor smoke detector shall be suitable for direct insertion into air ducts up to 3 ft (0.91m) high and 3 ft (0.91m) wide and with air velocities up to 5,000 ft/mm. (0-25.39 m/sec) without requiring specific duct detector housings or supply tubes.

The percent smoke obscuration per foot alarm set point shall be field selectable to any of five sensitivity settings ranging from 1.0% to 3.5%. The fixed temperature alarm set point shall be 1350F (570C) nominal.

The electronic assembly of optical Sensors shall be encapsulated in high resistively epoxy resin. The optical smoke Sensors shall incorporate an LED clearly visible from the outside to provide indication of alarm actuation.

**E-11R Heat Sensors :**
The heat Sensors shall be of the analogue addressable type. They shall be capable of detecting rapid rise in temperature and fixed absolute temperature.

The heat Sensors shall meet the requirements of either CL 521 or BS 5444: part 5 and BS 5445: part 8. The heat Sensors shall employ two heat-sensing elements with different thermal characteristics to provide rate of rise dependent response.

The temperature sensing elements and circuitry of heat sensors shall be coated with epoxy resin to provide environmental protection. The heat Sensors shall incorporate LED, clearly visible from outside to provide indication of alarm actuation.

**E-11S Addressable Manual Call Points :**
Addressable manual call points shall monitor and signal to the control and indicating equipment, the status of a switch operation by a “Break Glass” assembly. The addressable manual call point shall comply with BSEN54.

The addressable call points shall be capable of operating by means of thumb pressure and not require a hammer.

The addressable call points shall be capable of being mounted in a weatherproof casing with ingress protection to IP 66. The addressable call points shall incorporate a mechanism to interrupt the normal addressable Loop scan to provide all alarm response within less than 1 second and shall be capable of being tested using a special key, without the need of shattering the glass.

The addressable call points shall be field programmable to trigger either an alert or an Evacuation response from the central indicating equipment. The addressable call points shall provide an integral LED to indicate activation.
Al inscriptions on the manual cal points shall be permanently made on the cover and not on the glass. The alarm condition shall be maintained until reset by an authorized person by means of a special tool provided for that purpose.

**E-11T Smoke Sensors in the Lift Lobby:**
Activation of any smoke detector in the lift lobby (if any) other than the main or lift machine rooms, shall initiate a signal to the lift control panel to cause all cars in all groups that serve that lobby to return non-stop to the main landing.

If the smoke detector at the main landing is activated, the cars shall return to an approved alternate landing (unless the fireman’s switch is in the "on’ position).

**E-11U Addressable Relay Output Module:**
The addressable relay output module shall provide a volt free changeover relay contacts operated by command from control and indicating equipment. The contacts of the addressable relay output module shall be rated at 1 amp at 24 volt DC. The module shall monitor the relay coil for open circuit and transmit the fault signal to control and indicating equipment.

The addressable relay output module shall be capable of deriving power for its operation, from the addressable loop. It shall have a red LED indication when the contact has operated.

**E-11V Addressable Contact Monitoring Module:**
The addressable contact monitoring module shall provide monitoring of the status of switched input signals from either NO or NC contacts. The module shall provide a red LED indicator when a contact has operated.

The addressable contact monitor module shall be capable of deriving its power directly from the addressable loop.

**E-11W Line Isolator Module:**
The line isolator module shall provide protection on the addressable loop by automatically disconnecting the section of wiring between two modules, where a short circuit has occurred.

The line isolator module shall derive power directly from the addressable loop.

The line isolator module shall provide a LED indication that the module has tripped.

**E-11X Alarm Sounders:**
All fire alarm sounders within the building shall have similar Sound characteristics except in areas of high background noise all alarm sounders shall operate within a frequency range of 600 Hz to 1000 Hz, unless this would be masked with background noise frequencies. Alarm sounders shall be wired either in detector loop circuits or on separate sounder circuits in accordance with the approved manufacturer’s standard design.

**E-11Y Fire Telephone Jacks:**
- Remote firemen’s telephone jacks shall be flush mounted
- Fire Tel. Jacks shall be connected into separate circuit for each Jack
- Jacks shall be with the inscription “FIRE FIGHTER TELEPHONE”.
- Provide one fire telephone handset enclosure at control room with 5 handset

**E-11Z Battery /Charger Console:**
Battery /Charger console shall be provided where it is not an integral part of the control panel and in which case it shall be a completely self-contained console enclosing both nickel cadmium batteries and automatic battery charger for dc power.

The charger shall be two-rate constant potential unit maintaining the batteries fully charged under all service conditions. After an AC power failure longer than 10 seconds, a timer shall automatically switch the charger to its high rate mode. Following the predetermined high-rate charge period, the timer shall automatically return the batteries to float charge. A remote initiation of the timed high-rate charge mode shall be possible.
The front panel shall include a d.c. voltmeter, a d.c. ammeter, indicator lights for float and high-rate charge modes, a push-button permitting manual initiation of the timed high-rate charge mode.

The front of the cabinet shall be provided with hinged doors held closed by magnetic catches. Built-in stepped steel shelves shall position the rows or translucent plastic cells for visual check of electrolyte levels.

Access to the charger compartment shall be by a lift-off top cover, held in place with screws.

The unit shall be ventilated through louvers. The cabinet shall be made of sheet steel finished in baked gray enamel.

The unit shall be provided with float potentiometer, high-rate potentiometer, ac & dc fuses failure alarm relay, 24 hour automatic timer, earth detectors, ac pilot light, etc.

**E-11AA Repeater Panel:**
The repeater panel shall be sited as shown on drawings. The repeater panel front fascia shall match the main fire alarm panel and also has the same operational function capability. The communication with fire alarm panel shall be by means of microprocessor based data communication system.

**E-11BB Graphic Terminal:**
- A PC based GCC (Graphic Command Central) shall be installed in the BMS Room. It shall be possible from the GCC to monitor and control all of the points within the entire Network.
- The unit shall have the following features:
  1. Monitor and control all points connected to the system
  2. Store the complete Network System Historical Logs.
  3. High-resolution color Graphics.
- The PC shall be the latest at time of purchasing with CD drive
- A parallel printer shall be provided in the same Room to keep a hard copy of all system events with stamped date and time.
- The operating system for the workstation shall be windows 2000 with multi-tasking facility

**E-11CC General Requirements:**
The fire alarm and detection system shall be integrated with associated and ancillary systems described in these specifications.

Indications and detectors associated and ancillary equipment shall be taken into account in calculating the maximum load of the fire alarm and detection system power supply. Faults in equipment for other functions shall not affect the performance of the fire alarm and detection system.

Circuits of all signals to and from ancillary systems via potential free contacts located in fire alarm control panel shall be monitored by fire alarm control panels. Fire alarm system must always take priority over all the ancillary systems and shall not be delayed in operation by any automatic or manual event.

The layout of control panels of the integrated security system in the central control room shall be arranged so that the fire alarm controls cannot be confused with other controls. All faults shall be registered by audible and visible fault alarms. The visible fault alarm shall be in yellow LED’s.

All parts of other ancillary systems not directly connected to fire alarm system, but essential for its continued operation shall be monitored.

**E-11DD Conduits:**
Conduits shall be used where MICC cables are not used or when an alternative cable is considered by the contractor.
Conduits shall be rigid steel type where used exposed and non-metallic rigid PVC type where used embedded or above false ceiling, to the approval of Engineer and of local civil Defense Authorities.

**E-11EE Cables:**
Cables shall be as specified under ‘WIRES & CASLES”. All wires and cables of the system shall be sized to avoid any unacceptable voltage drop.

**E-11FF Inspection and Verification:**
1. Upon completion, arrange for the manufacturer to make a complete inspection and adjustment of the system including all components, to ensure that:
   - The system complies with the contract documents, the manufacturer’s recommendations, and the applicable codes and standards
   - The system functions in accordance with the drawings and specification in both the supervisory and alarm modes, including testing or operation of all alarm initiating devices to verify their operation and zoning.

2. During the inspection, provide staff as requested by the manufacturer as well as any required equipment such as ladders and scaffolding. Obtain information on staff requirements from the manufacturer before submitting a tender.

3. Submit the following to the Engineer:
   - Certificate of verification confirming that inspection has been completed and listing the conditions on which the inspection and verification are based.
   - Test report on all equipment checked during verification, including panels.
   - Annunciators, bells, manual stations and automatic detectors.

**E-11GG Testing and Commissioning:**

1. **Preliminary Tests**
   Upon the completion of the installation, the system shall be subject to functional and operation performance tests including test of each installed initiating and notification appliance. Tests shall include the meggering of all system conductors to determine that the system is free from grounded, shorted or open circuits. The megger test shall be conducted prior to the installation of fire alarm equipment. If deficiencies are found corrections shall be made and the system shall be re-tested to assure that it is functions.

2. **Acceptance Test**
   Provide the service of competent. Factory-trained engineer or technician authorized by the manufacturer of the fire alarm equipment to technically supervise and participate during all of the adjustments and commissioning of the system. Testing shall be in full accordance with NFPA 72 section 7.2.2.

3. Testing shall include all auxiliary functions, such as elevator recall, fan shutoff, and damper operation. The use of open flame or live smoke will not be permitted.

4. Submit seven (7) copies of the approval certificate and verification report to the Engineer after completion. Insert one (1) copy in the operation and maintenance manuals.

5. Demonstrate complete system to Civil Defense for their approval and certification.

End of Sub-Section (E-11)
SECTION E-12

TELEPHONE AND DATA SERVICES

E-12A GENERAL:
This section specifies the furnishing and installation of necessary equipment and materials and making arrangements for the connection of telephone and high-speed data transmission. All should comply with service installation standards of Palestine Telephone Authority (ITTISALAT). Service to the project should be via Underground PVC pipes.

E-25B COORDINATION:

The location of the service entrance must be coordinated with the telephone company. Provide materials and equipment required to enable the telephone company to connect service to the project.

The contractor shall attend and afford all facilities to the ETISALAT and shall take prior written approval of the adequacy of the proposed conduits for the telephone system.

Coordinate work of this section with Owner’s telephone switch, telephone instrument, work station, and LAN equipment suppliers.

E-25C LOCATION:

Secure approval from the Owner for the final locations of telephone and Data outlets. The contractor should make necessary coordination with ITTISALAT to have the right place and position of the work. The contractor should provide shop drawings and should have the approval from the engineer before he starts the work.

E-12D MATERIALS:

1. In interior spaces use cable trays and PVC conduit for telephone and data services. Use 3/4-inch minimum conduit with insulated bushings at each termination and install a pulling line in each raceway.

2. Provide boxes in accordance with the work.

3. Twisted-Pair Cables, Connectors, and Terminal Equipment
   A. Conductors: Solid copper.
   B. UTP Cable: Four thermoplastic-insulated, individually twisted pairs of conductors; No. 24 AWG, color-coded; enclosed in PVC jacket.
   C. STP Workstation Cable: Two thermoplastic-insulated, individually twisted pairs of conductors; No. 22 AWG, color-coded, overall aluminum and polyester shield and No. 22 AWG tinned-copper drain wire; enclosed in PVC jacket.
   D. UTP and STP Plenum Cable: Listed for use in air-handling spaces. Features are as specified above, except materials are modified as required for listing.
   E. UTP Cable Connecting Hardware: IDC type, using modules designed for punch-down caps or tools.
      1. IDC Terminal Block Modules: Integral with connector bodies, including plugs and jacks where indicated.
      2. IDC Connecting Hardware: Consistent throughout Project.
   F. Cross-Connect Panel: Modular array of IDC terminal blocks arranged to terminate building cables and permit interconnection between cables.
      1. Number of Terminals per Field: One for each conductor in assigned cables.
      2. Mounting: Backboard or rack as indicated.
G. Patch Panel: Modular panels housing multiple, numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
   1. Number of Jacks per Field: One for each four-pair UTP cable or two-pair STP cable indicated
H. Jacks and Jack Assemblies for UTP Cable: Modular, color-coded, RJ-45 receptacle units with integral IDC-type terminals. Use keyed jacks for data service.
I. UTP Patch Cords: Four-pair cables in (1200-mm) lengths, terminated with RJ-45 plug at each end. Use keyed plugs for data service.
J. STP Patch Cords: Two-pair cables in (1200-mm) lengths, terminated with STP plug connectors at both ends. Match plug connectors with patch-panel connectors.
K. Workstation Outlets: Dual jack-connector assemblies mounted in single or multi gang faceplate.
   1. Faceplate: High-impact plastic; color as selected by Architect.
   2. Mounting: Flush, unless otherwise indicated.
   3. Legend: Factory label top jack, "Voice" and bottom jack, "Data"; by silk-screening or engraving.
A. Plenum Cable: Listed for use in plenums.
B. Cable Connectors: Quick-connect, simplex- and duplex-type SC couplers with self-centering, axial alignment mechanisms. Insertion loss not more than 0.7 dB.
C. Patch Panel: Modular panels housing multiple-numbered duplex cable connectors.
   1. Permanent Connection: Permanently connect one end of each connector module to installed cable fiber.
   2. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to satisfy specified expansion criteria.

**E-12E EXAMINATION:**

Examine pathway elements intended for cable. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation. Proceed with installation only after unsatisfactory conditions have been corrected.

**E-12F INSTALLATION:**

2. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where cable wiring method may be used. Use UL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and wiring except in unfinished spaces.
3. Install cable using techniques, practices, and methods that are consistent with Category 6 rating of components and that ensure Category 6 performance of completed and linked signal paths, end to end.
4. Install cable without damaging conductors, shield, or jacket.
5. Do not bend cable in handling or in installing to smaller radius than minimums recommended by manufacturer.
6. Pull cables without exceeding cable manufacturer's recommended pulling tensions.
A. Pull cables simultaneously if more than one is being installed in the same raceway.

B. Use pulling compound or lubricant if necessary. Use compounds that will not damage conductor or insulation.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage media or raceway.

7. Install exposed cable parallel and perpendicular to surfaces or exposed structural members, and follow surface contours where possible.

8. Secure and support cable at intervals not exceeding (760 mm) and not more than (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

9. Wiring within Wiring Closets and Enclosures: Provide adequate length of conductors. Train conductors to terminal points with no excess. Use lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radius than minimums recommended by manufacturer.

10. Telephone outlets shall be cord grip type and shall consist of terminal blocks of high insulating phenolic block with non-ferrous screws and straps.

11. Telephone outlets shall be MK 4817WH1 Crabtree 7283. Unless otherwise specified or indicated to the approval of the Engineer.

10. All exposed cables wires cable ladders and their fixing should be fire retardant.

11. The contractor should install heavy duty Ladder support for all cables and conduits, (Class .acc. to DIN VDE O639).

END OF SECTION (E-12)
SUB-SECTION E-13

TESTS & CERTIFICATES

E-13A GENERAL:

After completion of the Electrical Work, the complete systems shall be tested thoroughly before commissioning. Any modifications or repairs necessary on completion of the tests shall be done at the Contractor's expense.

The tests outlined herein shall be in addition to, and not substitution for, the tests of the individual items at the manufacturer's plant. Insulation and grounding resistance test shall be made before operating tests. Proper rotation shall be determined before permanent connections are made.

All testing equipment on Site shall be provided by the Contractor. The Contractor shall make the necessary openings in the circuits, for the testing instruments and shall place and connect all instruments, equipment, and devices necessary for the tests. Upon completion of the tests, these shall be removed and all circuits connected to their permanent condition.

The tests shall be conducted in the presence of the Engineer and local power authorities representative.

The Engineer shall be notified seven calendar days or more in advance when any test is to take place, and it shall not be started without his permission.

Certificates when so required shall be submitted for any equipment installed under this contract originating by an authorized inspecting body in the country of the manufacturer.

Unless otherwise specified, the Contractor shall supply the electric current necessary for the tests.

The Contractor shall state and guarantee the particulars as specified in his tender documents. Such guarantees shall not be departed from without written permission by the Engineer. If such guarantees are not respected, the Engineer has the right to reject the faulty equipment.

The Contractor shall submit four copies of all tests results.

Test shall include the following:
- Insulation megger tests on wires.
- Continuity and resistance tests.
- Socket outlets proper wiring tests.
- Operational tests on all electrical equipment.
- Insulation resistance tests of motors.
- Testing of lighting installations.

E-13B INSULATION MEGGER TEST:

Tests for insulation level shall be a 500-volt Megger. A minimum of one mega ohm (1,000,000 ohms) applying to the complete installation shall be obtained. This means that when all the phase wires at the panel board are connected together and to the testing instrument, all switches closed, all appliances inserted in the circuit, all neutral wires left in the air, and the other end of the Megger is connected to the grounding, then there shall be a minimum of 1 mega ohm between the whole of the installation taken together and the grounding.

E-12C CONTINUITY & RESISTANCE TEST:

A continuity test to ensure that all connections have been made properly.
Test shall also include ensuring all switches and other interrupting devices breaking the phase wire and not the neutral wire.

Test shall include, in addition to checking continuity of current carrying wires and cables, continuity of grounding conductors. This shall be done through a Megger which shall produce an alternating current of a magnitude equal to one and a half times the rating of the circuit under test with a maximum of 25 amps.

E-12D SOCKET OUTLETS PROPER WIRING TEST:

All socket outlets shall be connected properly such that looking at the face of the socket outlet the live connection shall be on the right, the neutral on the left.

E-12E OPERATIONAL TEST:

The Contractor shall demonstrate the proper operation of circuit breakers, switches and any other equipment as requested by the Engineer, or as specified elsewhere in these Specifications.

Each motor and associated equipment shall be run as nearly as possible under normal operating conditions for as long a time as is necessary to demonstrate correct alignment, wiring capacity, speed, and satisfactory operation. The motor shall be loaded to full capacity, or as near there to as possible.

E-12F INSULATION RESISTANCE TESTS OF MOTORS:

All motors shall be tested for insulation in accordance with the requirement of IEC Standard Two copies of the test data shall be submitted.

E-12G TESTING OF LIGHTING INSTALLATIONS:

The Contractor shall demonstrate the proper operation of all lighting fixtures.

End of Sub-Section (E-12)
Section 1

1. Special Requirements

1.1 General
The contractor will be responsible for the co-ordination of all sub-contracted work and for the ensuring that such work is carried out in accordance with the master construction program. The contractor will be responsible for ensuring that the specified number of copies of all material and Equipment orders as well as details of sub-contact agreement s are submitted to the Architect-Engineer as and when these become due under the terms of sections 1, 2 and 3.

1.2 Rejection
All work shall be to the satisfaction of the Architect-Engineer. Any work condemned by the Engineer shall be removed and rebuilt or replaced by the contractor free of charge in a satisfactory manner as governed by this specification and all work distributed, injured or destroyed in the course of removal of the said condemned work shall be made good at the contractor's own expense.

1.3 Erection
The contractor shall provide all lifting beams and slings for moving and erecting plant at site, unless otherwise specified. He also shall provide, erect, alter as required and alternatively remove all temporary scaffolding required to facilitate erection of works.

1.4 Accessibility
All work shall be so installed as to be accessible for operation, maintenance and repair, deviations from the drawings may be made to accomplish this, but no change will be made without the written approval of the Engineer Access door locations shall have the approval of the Engineer before the work is installed.

1.5 Storage of Materials and Equipment:
All Materials and Equipment are to be stored in a manner so as not to obstruct the work of other Contractors and shall be adequately protected at all times so as to prevent corrosion, deterioration and ingress of foreign matter. All equipment must be kept clear of the floor or ground by means of wooden bearers of other means.

1.6 Prevention of noise and Vibration
Provision has been made to minimize noise and vibration. However different manufacturers, equipment will have varying sound and vibration characteristics. At tender stage, the contractor must carefully check the construction details to ensure that the equipment he is to offer will not transmit noise or vibration. All equipment installed in plant rooms and outside areas must not be audible in the occupied areas. Any addition or structure necessary to ensure compliance with the noise and the vibration requirements should be clearly stated in the Schedule forming part of this tender. Any vibration isolators, isolating bases, flexible connections, silencers or other acoustic treatment or anti-vibration precautions necessary should be included in the rates for the equipment. Acoustic sleeves around ducts, pipes and other items must be provided in walls, roofs and floors to prevent noise being transmitted from a plant room to an occupied area or from one occupied area to another. These must be supplied and approved prior to Installation. Attenuators must be fitted to prevent sound traveling through ducts, transfer grills or other openings, from one occupied area to another. Any opening such as electrical outlet boxes placed back to back in different rooms or waste pipes connected from room to room will not be permitted.

1.7 Spare Parts
The contractor shall provide as part of this Contract all special tools required for equipment maintenance and sufficient spare parts for each item of equipment to provide maintenance, all in accordance with the recommendations of the manufacturers of the equipment and as called for in the Schedule.

1.8 Guards
All moving parts of machinery must be protected by means of strong guards to adequately protect all personnel working on or in the vicinity of equipment. All live parts of electrical
equipment shall be protected in a way as to adequately safeguard from injury all personnel working on or in the vicinity of equipment. Wherever possible all protective guards should be supplied by the equipment manufacturer. All guards must be strongly attached to equipment and should be designed to be easily removed for access, serving, adjusting and maintenance.

1.9 Training of Employees
The Employer reserves the right to appoint, at his own expense, a reasonable number of technical staff who will be assigned to the Contractor’s erection team, to whom they will be directly responsible, for the whole of the erection period or any part thereof. Furthermore, the contractor shall be responsible during the maintenance guarantee period, for the supervision and training or the Employer’s staff assigned to the operation and maintenance of the plant installed.

1.10 Guarantee
The Contractor shall guarantee in writing to the Engineer that all work installed by him shall be free from any and all defects in workmanship and materials and that all apparatus will withstand variations in temperature, pressure, load and atmospheric conditions which arise under working conditions without undue distortion or deterioration, or setting up of undue stresses and strains in any part and of such magnitude as to offset the strength and suitability of the various parts. It should also be guaranteed that all plant will develop the capacities and characteristics indicated on the drawings or schedules, and that if during a period of one year from date of the certificate or completion and acceptance of his work, any such defects in workmanship, materials or performance appear, he will remedy them. All costs involved in carrying out this work shall be borne by the contractor.

1.11 Progress of Work
The contractor will be required to organize the progress of his work in a very thorough manner so as not to delay his own work or that of sub-contractors. The contractor must satisfy himself that he has all necessary data from the Engineer and sub-contractors regarding the scheduled completion dates for various sections of the building. All charts, requests, test reports and applications for the approval must be submitted in the manner and at the times laid down in this volume of specifications.

1.12 Site Meetings
During the course of the work, site progress meetings shall be held at regular intervals as directed by the Engineer for the purpose of coordinating the contractor’s work and those of sub-contractors to ensure full compliance with this paragraph. Minutes of such site meetings will be recorded. Copies will be distributed to all persons concerned and full effect shall be given to all instructions contained therein.

1.13 Rate of Work and Engineer’s Approval
The contractor shall, during the period of manufacture and erection on site, submit to the Engineer every month four copies of progress reports based on the program. As each part of the works is erected, it shall be checked by the Engineers. This applies particularly to leveling, setting and aligning, but any approval given shall in no way relieve the contractor of his obligations under the contract. The Contractor must give 48 hours notice in writing to the Engineer, detailing work to be approved. The contractor shall check all electrical and mechanical connections to all equipment supplied under the contract before such equipment is brought into operation, and shall be responsible for correcting any errors therein according to contract drawings and specifications.

1.14 Time for Completion
The time for completion shall be as stated in the contract for the whole works or as agreed on the time progress chart for any portion of the works.

1.15 Extension of Time
Extension of time for the whole or any part of the works will only be valid if approved in writing by the Engineer. Any alteration in the progress of the works must be entered onto the time progress chart.

1.16 Certificate of completion
The taking-over date for any of the plant being installed in accordance with the contract shall be the date at which the Employer signifies in writing his approval that the tests of completion have been carried out satisfactorily and agrees to have the plant operation by his employee. The taking-over of the plant by the Employer shall not be unreasonably delayed and should not be longer than one calendar month after the Engineer gives written approval of the test on completion.

1.17 Maintenance Certificate
The Maintenance period shall commence from the date the Engineer gives written approval of the tests on completion. Provided that all conditions of the maintenance and guarantee have been fully complied with by the contractor, the maintenance certificate will be issued one year after the date of approval of tests on completion.

1.18 Drawing Submittals and Instructions
The contractor shall be furnished with one copy of all detail drawings and graphic instructions prepared by the Engineer. Additional copies, within reasonable quantity, shall be furnished to the contractor upon request, at extra cost. The contractor shall be furnished with on copy of all written instructions as may be issued by the Engineer. The Engineer shall supply to the contractor, during the progress of the works, detailed drawings and instructions as may be necessary for the guidance of the contractor in the construction, completion and maintenance of the works, and the contractor shall execute, obey and be bound by the same. Should the contractor require additional information of the structure or other details, he must inform the Engineer within 14 days of receiving the drawings appertaining to the section of the building where additional details are required. The contractor shall not be entitled to any payment in addition to contract price in respect of any work shown or directed, to be done by such detailed drawings or instructions unless the Engineer shall have given and approved a variation order for the same. Any additional drawings found necessary or desirable by the contractor to show different combinations of drawings supplied by the Engineer shall be prepared by the contractor at his own expense. The contractor shall carefully check all drawings and advise the Engineer of any errors or omissions discovered.

1.19 Sample Shop Drawings
Sample “Shop Drawings” That the contractor has prepared for previous projects must be submitted with the tender. These drawings should be as called for in the schedules. Should any sample drawing require modifications or additions to bring it up to the standard required by these specifications, these must be added before the contract, before tendering.

1.20 Shop Drawings

1.20.1 General:
All drawings, other information and samples must be supplied to the Engineer as laid down in these specifications and as and when agreed during site meetings, in the progress chart or as instructed by the Engineer. The contractor shall prepare and submit detailed shop drawings for all equipment or distribution services described herein. Equipment layout shall be detailed on the drawings, showing the exact method of installing and clearly illustrating components to be used in making all connections. Clearance around equipment shall be made available for tube withdrawal and maintenance. Standard symbols with detailed legend must be used throughout. The contractor shall submit all drawings within the time specified. All drawings shall be supplied in the form of a second negative and signed by a principal of the contractor. After approval, the negative will be signed by the Engineer and returned to the contractor. The contractor shall supply the Engineer with six prints from this negative. Signed and approved drawings shall not be departed from unless a signed variation order or site instruction is issued in writing by the Engineer. Drawings returned to the contractor for alteration amendment are to be resubmitted to the Engineer for approval. Amended or altered drawings shall be in a revision block, on the drawing, together with the revision number or letter and the date of the revision. The contractor shall be responsible for any discrepancies, errors or omissions in the drawings and other
particulars supplied by him whether such drawings and particulars have been approved by the Engineer or not, provided that such discrepancies, errors or omissions are not due to inaccurate information or particulars furnished in writing to the contractor by the Engineer. Should the contractor prove unable to produce satisfactory “shop drawings” or be unable to produce drawings to conform to the progress of the works, the Engineer reserves the right to take whatever steps are necessary to have drawings undertaken by others and debit the contractor’s account. Any decision taken by the Engineer to have shop drawings produced elsewhere will not relieve the contractor of his contractual obligations and the contractor must provide to the Engineer all necessary details, performance curves, physical dimensions, descriptive literature, etc., of all equipment to be incorporated on drawings within 7 days of a request from the Engineer.

1.20.2 **Drawing sizes**
Sizes of drawing shall be as specified in this volume unless otherwise directed or approved by the Engineer.

1.20.3 **Co-ordination of Drawings**
The work described on any shop drawing submitted shall be carefully checked by the contractor for all clearance, field conditions, maintenance of architectural conditions and proper co-ordination with all trades on the job. To this end, the contractor during the production drawing stage shall insure that he receives drawings of all other trades that might interfere with the proper installation of his work. No payment shall be made for any variation or alternations on site due to lack of knowledge of the site. Any unresolved dispute shall be referred to the Engineer for decision. All points where many services are in close proximity, or there is limited space to install, or where the integration and connection of many services together requires clarification, large scale details must be prepared showing all services and clearances, such areas include false ceilings, shafts, plant rooms areas etc.

1.20.4 **Buildings, Work drawing and Schedules**
The contractor shall prepare schedules and drawings showing precise details of holes in concrete block-work, etc, bases, cables trenches and drainage of trenches, frames or supports required and the like. The schedule shall show in detail the builder’s work required to be performed. These drawings and schedules, in an approved form, must be submitted to and approved by the Engineer before any structural work requiring holes or other modification in contracted.

1.20.5 **Piped Services**
Piping runs and connections are indicative only. Precise routing and method of making connections to equipment must be detailed by contractor to suit the equipment offered, all in accordance with this specification and drawings. Pipe-work drawings must show all pipe-work in double line and indicating the precise size of fittings, valves and equipment. Positions of hanger supports with reference number must be indicated and a large scale detail must be given showing the type and method of installation in each drawing, showing details of the type of hangers’ fixings and reference number for each type. Diagrammatic charts showing schematically all systems and equipment with references and all valves with numbers as shown on their tags.

1.20.6 **As Installed Drawings**
The contractor shall supply to the Engineer “As Installed” drawings all in accordance with the requirements for “Shop Drawings” updated to show the exact way that equipment is installed and shall be completely cross referenced to submittals and instruction manuals, so that they form an integrated reference to details of equipment, method of installation and maintenance. Six copies of each drawing shall be supplied. The contractor shall provide complete sets of diagrammatic charts. One set to be printed on heavy linen and mounted in glazed frames. Charts to be fixed in plant rooms as instructed by the Engineer.

1.20.7 **Manufacturer’s Data and Submittals**
Manufacturer’s performance data and certified factory drawings giving full information pertinent to the adequacy of the submitted equipment shall be submitted for approval. Submittals are to be made in a manner to ensure complete information regarding what is being offered and in a manner that facilitates easy filing and ready access to all data, throughout the contract period. Submittals and shop drawings should, as far as possible, be complementary, so that drawings and submittals can be cross-checked. Where data, certified drawings or other required information is not available until after orders have been placed, the Engineer will give provisional approval until all requested drawings and information have been supplied to the Engineer and approved by him. It is the contractor’s responsibility to ensure that all necessary information is supplied to the Engineer in accordance with the progress of the work. Should the Engineer give provisional approval only, of an order, due to lack of complete information and should the missing information not eventually meet with approval, the Engineer will not be held responsible for any delay incurred. For equipment where information from the manufacturers is likely to be delayed, it is essential that the contractor places provisionally approved orders at the earliest possible date, so as to ensure approval of orders in complete conformity with the progress of the works. Submittals must be made on a standard size sheet and supplied with three sets of indexed binders each to hold the full set of submittals. As a minimum, submittal for each item must contain:

• Date submitted.
• Serial number, M1, M2, etc. for mechanical drawings. Amended or modified submittals to clearly show amendment A, B, etc., and amendment date. If any item is approved provisionally on site or by any other means a formal submittal must still be made and any evidence of previous approval attached.
• Performance schedule, where applicable, giving full description, details of air flow, gpm, b. h.p., kw, motor h.p., sound rating, weight, materials for contraction, operating pressures, etc., and other technical data to indicate that the material or equipment is completely in accordance with the specifications.
• List of deviations, if any.
• Full description of item. Manufacturer’s model number and type.
• Specification clauses and other information references.
• Location and reference number of item and shop drawings.
• List of curves, data, catalogues, leaflets attached to submittal. (Each catalogue to have clearly indicated on it by pen, the applicable model, performance data, etc.).
• List of optional items offered.
• List of test certificates, and certified drawings.
• Nameplate information.
• Each submittal to be in four copies, one of which will be returned to the contractor after comments and/or approval. If the Information is incomplete but sufficient for “preliminary approval” such approval will be given.
• Submittals to have three sets of catalogues, curves, drawing etc. attached.

1.21 Samples
The contractor shall submit to the Engineer samples and names of manufacturers of the materials for approval prior to ordering.

1.22 Measurements and Payment

1.22.1 General
Rates of all items of equipment & materials shall be inclusive of all labour, electric power during installation & testing, oxygen, water, transport, temporary works stores, offices, instruments, insurance, customs, duties, supply of all information & data, supply of catalogues, charts, curves, submittals, certified drawings & all other information & services called for in the specifications, all fully connected up & in good working order. Rates shall also include for:

• Marking positions of holes, mortises, chases, etc.
• Cutting and pinning ends of supports of structure.
• Cutting away for all ducts, holes, chasing, mortises, and making good at
1.22.2 **Equipment**

Equipment is enumerated in the bills of quantities & the rates for each item shall include painting, tags, nameplates, belt guards & all applicable accessories, and appurtenance, described in the scope of work & the specifications dealing with these items of equipment. Rates for equipment shall include for all bases and support, for connections to pipe-work, & electrical services for painting & all other work as specified or necessary for the complete installation.

1.22.3 **Duct area**

Duct area is to be calculated from the signed and approved shop drawings in compliance with the tender drawings as below: Supply air velocity for main supply air duct controlling factor noise generation Max 800fpm. A-area = length (m) X circumference (m) = sq.m. , both length & width of each section are to read off from the plans with proper conversion of units.

The weight calculated from this formula is the net installed area of each section without any consideration of waste.

1.22.4 **Piping**

Piping is to be measured net in linear meters along center line of pipe without measuring any tees, reducers, otherwise described are to include for pipe fixings of suitable design & type to be spaced at centers necessary to obtain adequate support & the required fall. All pipe fixings shall be to the approval of the Engineer & the sufficiency of the fixings shall be the contractor’s entire responsibility. Rates for galvanized steel & copper pipes shall also include for elbows, bends, reducers, tees tank connectors, & all fittings of a similar nature & rates for insulation shall include for all necessary special fittings & prices for effectively insulating these fittings. Rates for all pipe-work shall include for all short or isolated lengths, jointing, cutting & waste, made bends, brackets, holder bates, sleeves, acoustic sleeves etc.

1.22.5 **Insulation**

Insulation to pipes is measured in linear meters & the rates shall include for:

- Preparation of surfaces.
- Painting surfaces as specified. Supplying, fixing & jointing the insulation complete over fittings, & metal clad mechanical fastenings on valves, tees, elbows, etc.
- Vapor barriers, plastering & painting of insulation as specified.

1.22.6 **Instruments**

Instruments not forming a part of equipment are enumerated & the rates shall include for all the requirements of the specifications.

1.22.7 **Controls**

Controls not forming part of equipment are as sets to be priced as a lump sum for each set.
1.22.8 **Bills of Quantities**

The Contractor shall refer also to bills of quantities for instruction in respect of rates & measurements.

1.23 **Schedules**

Contractors should note that the schedule requires a limited amount of information & that this information is to help the Contractor easily understand the requirements of the tender & to enable tenders to be easily evaluated. The contractor will be allowed slight variations from the data given, at the construction stage, providing that the standard stated or implied in the specifications is maintained & subjected to approval by the Engineer. Generally, major departures from information completed in the schedules at the time of tendering will not be permitted & will require approval with a written instruction from the Engineer. The Contractor will be required to provide considerably more information at the “Submittal” stage to indicate that each piece of equipment & material complies with the full intent of the specification & material being supplied. Names of manufacturers mentioned are not intended to be restrictive & are included to assist the Contractor in fully understanding the exact requirements. Well known manufacturers having equivalent products will be acceptable. However, items such as grilles, registers, diffusers & any items, material or equipment, having to fit in with the overall decorative scheme, should be as specified. Operating heads of pumps & external static pressures for fans where given are approximate. The contractor will be required to supply equipment to handle the requirements of his installation without extra cost to the contract.

1.24 **Test at Site**

1.24.1 **Acceptance Tests**

A. **General**

The contractor must give the Engineer three days written notice of his intention to carry out any tests. On completion of satisfactory tests the Engineer will give written approval. These tests are to be carried out on site after the completion of a part or whole of each piece of equipment or system & prior to any provisional acceptance of the work. The contractor shall submit to the Engineer, prior to the commencement of the tests, six copies of the complete test procedure. The procedures method & points of measurements as well as the method of calculation, shall be approved by the Engineer before any test is carried out. Six copies of the test results shall be furnished to the Engineer for his approval. The contractor shall supply skilled staff & all necessary instruments & carry out any test of any kind on a piece of equipment, apparatus, part of system or on a complete system if the Engineer requests such a test. Any damage resulting from the tests shall be repaired and/or damaged materials replaced, all to the satisfaction of the Engineer.

In the event of any repair or any adjustment having to be made, other than normal running adjustment, the tests shall be void & shall be repeated after the adjustment or repairs have been completed. All testing, balancing & final adjustment shall be in accordance with the provisions of these specifications. The contractor is to submit test reports by independent testing authorities to support compliance to BBS or any other standard mentioned in these documents or any local codes or regulations, if requested to do so by the Engineer. Test data shall not deviate by more than three percent (3%) from the guaranteed capacity data of the equipment installed unless otherwise stipulated under the specification clause for the item of equipment.

B. **Equipment**

All equipment included in this work is to be tested to indicate to the Engineer that it is functioning properly & fulfilling the requirements of the specification. All air handling & ventilating equipment, ductwork branches & air outlets shall be adjusted & balanced to deliver the specified air quantities indicated on the drawings at each inlet & outlet. The air quantities shall be within five percent of those specified. Volume dampers & splitter dampers shall be tested for
proper operation, functioning & performance; the latter shall be operated simultaneously with the equipment or system during tests. If air quantities cannot be delivered without exceeding the speed range of the sheaves or the available horsepower, the Engineer shall be notified before proceeding with the balancing of air distribution system. Other tests as specified under the specific equipment headings are to be completed to the satisfaction of the Engineer.

C. **Piping System**
Pressure tests shall be applied to piping only before connection of equipment & appliances. In no case shall piping, equipment or appliances be subjected to pressure exceeding their rating. Tests shall be completed & approved before any insulation is applied or pipes, valves & fittings have been concealed. Tests shall be performed in the presence of & to the satisfaction of the Engineer. Any leaks or defects uncovered by the tests shall be repaired & the system retested above, all at no additional cost to the Employer. All water piping shall be tested & proven tight under hydrostatic pressure of at least 150 % of maximum working pressure but at not less than 100 p.s.i. The prescribed pressure shall be maintained for eight hours. All refrigerant systems shall be tested & proven tight under nitrogen pressure of at least 150 % of maximum working pressure which shall be maintained at least eight hours. Before completely charging refrigerant the whole system shall have a holding charge & be tested for leaks by means of a leak detector.

1.24.2 **Test on Completion**
After carrying out the foregoing individual tests & making the necessary adjustments the contractor shall carry out tests on completion for the whole of each system provided that the progress of the installation is such that it is possible for the system or systems to be operated & taken over the Employer. All tests on completion are to take place before the reliability tests.

1.24.3 **Reliability Tests**
A. **General**
The contractor shall run reliability trials for the whole of the plant installed. Each trial shall last for a period of 31 consecutive days during which time the whole of the plant shall operate continuously without adjust or repair, to the satisfaction of the Engineer. Should any part of the apparatus or system fail to meet the specification requirements, it shall be adjusted, repaired to the satisfaction of the Engineer. The complete performance test and/or reliability trial shall then be replaced. The date of commencement of these tests shall be subject to agreement with the Engineer.

B. **Air Conditioning & Ventilation**
The whole of the trial of the plant shall take place during the appropriate season when design conditions are met or approximated. Normally this would be between the 31st May & 15th of September. The ventilation trial shall take place at reasonable time subject to the approval of the Engineer. During the reliability trial a further performance test shall be conducted on the refrigerating & air conditioning equipment.

1.24.4 **Maintenance Period**
During the maintenance period the contractor shall demonstrate to the Engineer that the equipment & systems are operating according to the capacities & the manner set down in these specifications. After completion of these tests the Engineer will issue a Maintenance Certificate for the part or parts of plant satisfactorily tested.

1.25 **Painting and Identification of Services**
1.25.1 **Painting**

All steel work in connection with supports for pipes, cables, ductwork, etc., exposed to the elements is to be painted with two coats of an approved rust preventive paint. All exposed metal surfaces of machinery, un-insulated pipe work, hangers' brackets, valves, etc., must be painted two coats undercoat & two finishing coats of enamel paint to an approved color. Identification bands shall be painted on piping or insulation at frequent intervals. Lettering & coloring shall be agreed upon in coordination with the Engineer. All exposed insulation in the plant room is to be painted to approved colors with one undercoat & one finishing coat of enamel paint. All steel pipe work & other steel equipment specified to be insulated shall be thoroughly wire brushed & painted to the satisfaction of the Engineer with one coat of black cold asphalted paint before insulation is applied. Internal surfaces of grills, diffusers & register boxes & connections visible to occupants of rooms, shall be painted two coats of dull black paint or other color, as described by the Engineer.

1.25.2 **Manufacturer's Nameplate**

Each unit of equipment shall be identified by a permanently attached nameplate in English made of brass or other corrosion resistant metal. Plates shall be not less in size than 38 mm x 75 mm. Plates shall bear information pertaining to the unit as follows:

- System and unit designation from schedule of equipment.
- Manufacturer’s name and address.
- Serial and model numbers.
- Rated capacity.
- Temperature, pressure or other limitations.

1.25.3 **Valve Tags, Charts and Nameplates**

All valves, dampers and controls shall be designated by distinguishing numbers in English on the charts or diagrams. The contractor shall provide stamped brass tags for all designed items with numbers corresponding to these on the charts. The tags shall be not less in size than 38 mm in diameter with depressed black numbers of 13 mm height. The contractor shall provide separate lists designating the location & function of each valve, damper & control. The charts, diagrams & lists shall be of sizes, type & character as approved. Upon completion of the work the contractor shall also tag all valves. All electric cable runs to be clearly tagged. The contractor shall furnish four sets of diagrammatic charts showing schematically the complete installation with major control valves, etc., & number thereof. Such charts shall be mounted in glazed frames & located as directed. Control panels, distribution boards and sub mains, gauges, thermometers, voltmeters, ammeters and other instruments shall be clearly indicated by engraved nameplates in English. Nameplates shall be black plastic with white laminated color.
Section 2


2.1 Scope of Work
The work under this section of specifications shall include the supply, installation, testing, commissioning and delivery in good operating condition the heating and ventilation systems specified in the present documents and/or shown on drawings.

2.2 Works Included
- The work shall include but not be limited to the following: Installation of a complete heating and ventilation system for exhaust requirements.
- Installation of a complete hot water system from the solar heating on roof.
- Installation of all temperature controls.
- Installation of all electric wiring and protective devices for the ventilation equipment.
- Installation of Air conditioning system.

2.3 Maintenance and Guarantee
All equipment and works shall be guaranteed for one full year of operation against all manufacturing and installation defects, fair wear and tear excluded. During the guarantee period, the contractor shall provide free maintenance for all equipment installed. The guarantee period shall start with the provisional taking-over of the systems.

2.4 General Requirements

2.4.1 Material and Equipment Generally
All materials and equipment shall be able to withstand variations in temperature, pressure, heat and atmospheric conditions which arise under working conditions without undue distortion or deterioration, or the setting up of undue stresses or strains in any part, of such magnitude as to affect the strength and suitability of the various parts.

2.4.2 Engineer’s Approval
As each part of the works is erected, it shall be checked by the Engineer if he so requires. This applies particularly to leveling, setting and aligning, but any approval given shall in no way relieve the contractor of his obligations under the contract. The contractor must give specified notice in writing to the Engineer detailing work to be approved. The contractor shall check all electrical and mechanical connections to all plants supplied under the contract before such plant is brought into operation and shall be responsible for correcting any errors therein according to contract drawings and specifications.

2.4.3 Accessibility
All works shall be so installed as to be accessible for operation, maintenance and repair. Deviations from the drawings may be made to accomplish this, but no change will be made without the written approval of the Engineer. Access door locations shall have the approval of the Engineer before the work is installed.

2.4.4 Storage of Materials And Equipment
All materials and equipment are to be stored in a manner so as not to obstruct the work of other trades and shall be adequately protected at all times so as to prevent corrosion, deterioration and ingress of foreign matter. All equipment must be kept clear of the floor or ground by means of wooden bearers or other means.
2.4.5 Training of Employees
The owner reserves the right to appoint at his expense, a reasonable number of technical staff who will be assigned to the contractor’s erection team, to whom they will be directly responsible, for the whole of the erection period or any part thereof. Furthermore, the contractor shall be responsible during the maintenance period, for the supervision and training of hospital owner’s staff assigned to the operation and maintenance of the plant.

2.4.6 Progress of Work
The Engineer will require a separate progress chart in full and complete detail specifically for the works contained in this section, together with proposals for placing of orders and receipt of materials on site. The progress chart, after agreement, will be incorporated in the main contract program for the works. The progress chart submit shall indicate on a day by day basis the various phases of work from the time of commencement of the contract to final completion of (.....) major item in this section and shall include design submission of drawings, ordering of material manufacturing, delivery, erection, testing, commission, completion and handing over. The following time table shall be read carefully:

- Preliminary progress chart and proposals to be delivering within (7 days of signing contract).
- Engineer will return this to contractor and discuss and agree to its final forms within (30 days after submittal by contractor).
- Contractor will receive and present to Engineer in final form within (15 days after agreement).
- After commencement of the works contained in this section the contractor, shall, in addition submit to the Engineer revised progress charts show actual progress on site at the following intervals (Monthly).
- The contractor’s progress charts are to show the latest dates on which he requires drawings from the Engineer detailing the various sections of the building. On receipt of these drawings the contractor must specify any information he may require within (14 days).
- The Engineer will require notice from the contractor of at least two days after receipt of the contractor’s request for approval of work completed or witnessing of tests. The progress chart submitted by the contractor for these works will be deemed to have allowed for such notice. The progress charts shall be submitted to the Engineer in the following number of copies:
  - preliminary charts 2 copies
  - charts after final approval 4 copies
  - Charts to be submitted each 4 copies
  - month after commencement of the works in this section
  - to show actual progress

2.4.7 Shop Drawing Manuals and Manufacturer’s Catalogues
In addition to what is called for under item 1.20.1 (general), the following shop drawings and instruction manuals shall be submitted for approval:

- Duct and pipe work drawings must show clearances between them and masonry. All dampers, splitter dampers, fresh air inlets, exhaust outlets, connections to equipment, piping, valves, controls and method of support and any other details necessary for the satisfactory installation of the system must be indicated. Each type of grille, register, diffuser and louver is to be referenced in a schedule and the type and size clearly indicated at each location. And upon completion of the installation.
- Step by step operating instructions for each system, including preparation for starting, summer operation, winter operation, shutdown and drainage.
- Complete, as installed, color coded wiring diagrams of the refrigeration systems and air handling systems, together with all electric motor controller connections of other mechanical equipment listed in the
2.5 Fans

i) General
Exhaust and return air fans shall be of approved quality and quite noise such as Wood or equal, supplied and installed by the contractor as shown on the drawings. The capacity, type and rating of the fans shall be as specified in the schedules. The fans motors and starters shall be in accordance with the specifications and electrical equipment.

ii) Axial Flow-inline ducted fans
They shall be of the single stage, direct driven by totally enclosed motor. The fans shall have the “L” type casings with external terminal boxes, extended lubricators and removal access doors. The fans shall be fitted with anti-vibration mountings and mounting feet supplied by the manufacturer. Fan will be supplied in rigid cylindrical casing fitted with heavy flanges and acoustically treated for low noise level.

iii) Centrifugal Fans
Centrifugal fans are to be of the single width forward curved pattern of the low pressure class 1 type. Fan intakes are to be designed for smooth air flow and close tolerance is to be maintained between wheel and intake panel. Frames are to be heavily constructed and from a compact rigid structure. Anti-vibration bases shall be fitted. Bearing shall be of the self-aligning sleeve type. Fans shall be driven by motors conforming with other clauses in these specification. Motors shall be mounted on anti-vibration bases with the fan and will drive the fan through an oversized v-belt drive.

iv) Roof Exhaust Fans
Roof exhaust fans shall be standard centrifugal roof exhausters. The housing shall be of hard aluminum rigidly braced with heavy angle iron frame and headed for additional strength. Fan motor drive and bearings shall be mounted above the fan wheel in a compartment isolating the components from the air handled by the fan.

Fans shall have a weatherproof hood hinged to the fan frame with stainless steel lock, in order to provide easy and ready access to the fan components. Fan wheel shall be of the backwardly inclined, centrifugal type, all welded construction having blades of not less than No.12 gauge and plated of not less than No. 10 gauge.

Fan shall be furnished with self acting louvers mounted in the curb below the fan; the duty shall be as indicated on the drawings.

Fan must be completely statically and dynamically balanced. Fan sound level must not exceed 50 db in ventilated area as a result of running the fan.

Fan motor must be totally closed.

Fan connected to ducts must have a flexible connection of canvas to be fixed by steel angles 3 cm x 3 cm.

Each fan motor must be connected on one bed plate of steel construction and erected on anti vibration mountings.

v) Extractor Fans
The contractor shall supply and install as shown on the drawings a range of vent axia extractors or equivalent of ratings as indicated on the drawings. Fan shall be either centrifugal or propeller type direct drive suitable for window or wall mounting. Fans shall be designed to ensure lowest noise level and each shall be supplied with its starter or switch and weatherproof hood. Fans shall be constructed from non corrodioble materials.

Fans shall be furnished with self acting louvers mounted on the face of fan.

The propeller will be strong and rigid giving large volinetric capacities and high efficiency, with non overloading characteristics and very quite operation.

The motor to be squirrel cage induced type suitable for continuous operation.

For wall mounted fan the motor to be attached to the fan ring by three arms of pressed steel.
Rubber inserts to prevent transmission of motor noise.

2.6 **Miscellaneous Items and Instruments**

2.6.1 **Vibration Isolation**
All pipe hangers must be insulated from the building either by cork insert between the pipe and hanger or, alternatively, by rubber pads between the hanger bar fixing and the connection, to the structure. Details of the contractor’s method of achieving this shall be submitted to the Engineer for approval. Flexible pipe connection details are to be submitted to the Engineer for approval.

2.6.2 **Oils and Greases**
The contractor shall supply in sealed containers, oils and greases of suitable quality sufficient for the initial charge plus one hundred percent (100%) extra. The grades of oil and greases and their manufacturer shall be approved by the Engineer.

2.6.3 **Tools**
The contractor shall supply, in a tool box a full set of tools suitable for erection of all components of the plant, including the electrical equipment. Another new set of tools for maintenance shall be also supplied after taking over.

2.6.4 **Instruments**
All instruments must be of first-class manufacture. Where possible, sizes and types of dials for instruments of various equipment should be grouped in panels and be similar in appearance. All gauges and dial type thermometers shall have plastic nameplates indicating their function.

2.7 **Pipe work and Fittings**

2.7.1 **General**
Each part of the piping system shall be complete in all detail and provided with all control valves and accessories necessary for satisfactory operation. The tender drawings indicate generally the sizes of all main piping and while the sizes are not to be decreased the Engineer reserves the right to change the runs and sizing of piping to accommodate conditions during construction. All piping shall be grouped wherever practical and shall be erected to present a neat appearance. Pipes shall be parallel to each other and parallel or at right angles to structural members of the building and shall give maximum possible headroom. All pipe drops shall be truly vertical. No joints shall be formed in the thickness of walls, floors or ceilings. The contractor is responsible for ascertaining the thickness of plaster and other wall finishes, skirting heights, cell lengths, and floor finishes. Pipe works shall generally be set around all columns and shall follow the contour of the building whether so indicated on the drawings or not. Piping shall not pass in front of doorways or windows and shall be generally arranged so that it is at least 8 cm above finished wall faces. Sufficient space is to be allowed for accessibility for servicing. Piping shall be pitched for proper circulation and drainage. Run outs shall be graded in such a manner as to prevent air traps being formed within them when the mains expand or contract. Automatic or open vents are to be provided at high points, piped to suitable drains or to terminate over expansion tanks. All drain piping shall pitch down in direction of flow.

All low points of the system must be fitted with drain valves to permit the complete drainage of the system. Bottom of all rises must have dirt pockets of the same size as that of the riser and at least 30 cm long with a drain valve fitted. All water piping to equipment and valves shall be connected with either flanges or unions for dismantling and removal. All piping shall be reamed after cutting to remove burrs. All reductions in sizes of piping in the direction of downward pitch shall be installed with eccentric fittings to maintain a level bottom. Piping shall not be installed passing through ductwork or directly under electric light outlets. When placing pipes through sleeves, near walls, partitions or in chases, care must be taken to provide sufficient space for
pipe covering. Where pipes are held in vices, as when screwing, care shall be taken to ensure that the pipe surface is not damaged. Any pipe work so damaged shall not be fitted. All pipes stored on site shall be kept clean and off the ground and where possible stored under cover. Pipes corroded beyond normal “stock rust” condition shall not be used.

Special care should be taken to prevent dirt and foreign matter entering open ends of pipes during erection. The contractor should note that a valve fitted to the open end of a disconnected pipe is not considered satisfactory to prevent entry of foreign matter. Screwed iron caps or plugs or plastic covers shall be used to seal pipe ends. Wood, rag, paper or other inadequate plugs will not be permitted.

Before connecting up to return mains, the systems of piping must be blown and flushed out. After flushing, all strainers shall be opened and baskets cleaned. Liberal allowance shall be made for expansion and contraction of pipes by means of changes in direction or by the inclusion of expansion joints in the piping system. All pipe-work valves, fittings, etc. are to be as detailed for the services in the schedules and bill of quantities.

2.7.2 Pipe installation

All piping shall be properly supported or suspended on stands, clamps, hangers, etc. of approved design. Supports shall be designed to permit free expansion and contractions while minimizing vibration. Pipes shall be anchored as directed by means of steel clamps securely fastened to the pipe and rigidly attached to the building structure. Screw threads shall be cut clean and true and joints made tight without caulking. No bushing shall be used. Reducing fittings shall be used to change pipe size, and reductions to be made with eccentric reducers, short radius fittings shall not be used.

The drawings indicated generally the size and location of piping as designed for space conditions; ceilings heights and may not be changed until coordinated other contractors. If it is seemed necessary to modify the piping system the contractor shall size the pipes on the basis of 3-6 fps. Velocity and re-check pump heads which are presently indicative and for purposes of an estimate.

Pipe work shall conform fully of the following requirements. Piping shall be properly graded to secure easy circulation and prevent noise and water hammer. As much pitch as space conditions allow must be given. Capped dirt pockets to be installed at all risers heel, low points, and other places where dirt may accumulate must be provided. Allowance must be made for proper provision for expansion and contractions in all portions of pipe work to prevent undue strain in piping or machines. Expansion joints to be installed as directed by the engineer.

All fittings such as elbow, tees, bushes etc...shall be of best quality foreign made or local class “A” according local standard with smooth interior surfaces. Approved screw unions with bronze or steel bodies and ground brass taper or spherical joints shall be installed at traps instruments, etc... and where else directed to permit easy connection and disconnection.

If after the plant is in operation any fan coil or A. H. Units do not circulate quietly and noiselessly (due to trapped or air-bound connections), the contractor shall make proper alterations in these defective connections. If connections are concealed in furring, floors, or ceilings, the contractor shall bear all expense of tearing up and rebuilding construction and finish.

Final connection to equipment and Fixtures shall be made in manner that will permit the complete removal of any fixtures or any piece of equipment without cutting of pepe line.

All main shall have a slope of not less than 5 mm in 3 meters in the direction of flow. All branch shall have a slope of not less than 1 mm in 3 meters towards the main. All branches from mains shall be connected at the angle of 45 if possible. Each piece of pipe and each fitting shall be carefully inspected on the inside to see that there is no defective workmanship on the pipe or obstructions in the pipes or fitting. Joints in all screwed pipiing shall be made with red lead and boiled linseed oil completely covered the male threads.
Straight Elbows, bushing, long screws, or bull head tees shall not be installed, and all officets shall be made with fittings. Pipes shall not be bent at any time.

Pipe work shall be installed in manner to allow for ease of air escape and system draining it shall be endeavored to obtain this naturally by gravity. However, where conditions do not permit it an automatic air vent shall be installed at all air pocket locations and drain gate valve shall be supplied and installed at all low points and risers legs.

### Materials for piping

<table>
<thead>
<tr>
<th>Service</th>
<th>Material</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilled water</td>
<td>Steel</td>
<td>Black Schedule</td>
</tr>
<tr>
<td>Hot water for heating</td>
<td>Steel</td>
<td>Black Schedule 40</td>
</tr>
<tr>
<td>Domestic hot and cold water</td>
<td>Steel</td>
<td>Galvanized Schedule 40</td>
</tr>
<tr>
<td>Vent, feed, expansion</td>
<td>Steel</td>
<td>Galvanized Schedule 40</td>
</tr>
<tr>
<td>Drain and condensate</td>
<td>UPVC</td>
<td>Polyvinyl chloride-SN4,SN8</td>
</tr>
<tr>
<td>Fire fighting pipe &quot;cabinet&quot;</td>
<td>Steel</td>
<td>Galvanized Schedule 40</td>
</tr>
<tr>
<td>Fire fighting sprinkler</td>
<td>Steel</td>
<td>Galvanized Schedule 10</td>
</tr>
<tr>
<td>Gas pipe</td>
<td>copper</td>
<td>Type K</td>
</tr>
<tr>
<td>Refrigerant gas and liquid</td>
<td>copper</td>
<td>Type K</td>
</tr>
</tbody>
</table>

All piping black steel up to 11/4" shall be screwed and socketed with threaded fittings. All piping including 11/2" and above shall be welded or screwed and socketed. All steel welding elbow shall be of the long radius type except where space conditions do not allow. Joints shall be but welded single V type, elbow and fittings formed of welded cut pipe section will not be acceptable. No piping shall be hung from other piping and all hangers shall be of heavy construction suitable for the size of pipe being supported. All piping in the machine room shall provided with rubber in shear vibration eliminating hanger.

- **Welded Joints**
  
  Care shall be taken to ensure that welding or flux does not project into the bore of the pipe. All welds shall be of good clean metal, free from slag and porosity, of even thickness and contour, well fused with the parent metal, hammered on completion and finished smooth. The Engineer receives the right to have cut for examination 2% of all welds made. The contractor shall re-make the joints at his own cost. All welded joints (except pipe welded end-to-end) shall be made by use of forged one piece, welding flanges, caps, elbows, branch outlets and tees of approved make. All such fittings, etc., shall be of a type which maintains full wall thickness at all points, ample radius fillets, and proper levels or shoulders at ends. Cut and formed multi sectional elbows or pipe cut and formed to reduce pipe size thus eliminating reducers, will not be permitted. Job welding may be by electric arc welding or the acetylene process.

- **Screwed Joints**
  
  Screwed joints on steel piping shall be clean threaded, pulled up tightly and made with approved jointing compound and long strand hemp. After joints have been formed, all surplus hemp should be cut away and the joints wiped clean. Alternatively, P.T.F.E. Taps may be used. Where galvanized piping is used, care shall be taken to ensure that threads are carefully cut, so that the number of exposed threads is minimized.

- **Flanged Joints**
  
  All flanged joints shall be flush and truly aligned and made with approved corrugated rings, compressed asbestos or composition joints. Flanges for connection to welded pipes shall be “slip on” or welding neck standard steel type made as indicated in the schedules. Flanges or unions shall be provided on straight runs at not greater than 12 meter intervals. Wherever possible, at piping connections to
equipment, valves or other units requiring maintenance, servicing, or possible removal, the connecting joint shall be made by means of unions or flanges. Pressure rating or flanges shall match the pressure of the flanges on the equipment to which the pipe connected.

- **Unions**
  Unions are required on pipe 50 mm and under. Unions shall be ground taper joint type good for 8.37 Kg/sq. cm working pressure. Unions shall have bronze conical seats ground in. Flat unions shall not be used.

- **Flexible Connections**
  Flexible couplings shall be such that the working pressure, temperature and movement encountered will not be more than 75 % of that allowable for the joint. One side of joints must have all piping and/or adjacent equipment adequately anchored. The other side must be supported, aligned and guided so as to allow free movement without imposing unnecessary stress on the joints. Couplings shall have integral duct and rubber flanges. They shall have individual solid steel ring reinforced with a carcass of highest grade woven cotton or acceptable synthetic fiber. Joints shall be constructed to pipeline size and to meet working pressure, conditions and face measurements as designated. They shall be of an arch type construction with the number of arches (Corrugations) depending on the protected movement. All joints must be finish-coated with Eypalon paint to prevent zone attach. Split back-up (or retaining) rings shall be furnished and fitted.

- **Bellow Expansion Joints**
  Expansion bellows shall be of axial pattern or as indicated and shall be provided with screwed or flanged ends as appropriate. They shall be manufactured from 18/8 stainless steel or other approved material appropriate to the duty and shall be designed to withstand the test pressure of the system. Bellows shall be capable of not less than 2000 complete cycles of movement over the designed working range without failure. Expansion bellows for angular movement shall be provided with tie rods or hinges to take end thrust. All bellows expansion joints shall be provided with external protection where exposed to damage. For axial bellows this shall comprise an extreme sleeve. Bellows shall be installed so that they are not subjected to stresses other than those for which they are designed. They shall be installed so that they are in their free position at a temperature midway between the high and low limits of normal service. Bellows expansion joints shall be provided with guides to ensure that all movement is taken up in the designed manner. The manufacturer’s recommendations shall be closely followed. Guides shall be secured rigidly and shall provide free movement for expansion without undue tolerance. Means for lubrication shall be provided where necessary.

**2.7.3 Pipe Supports and Anchors**
All supports for steel piping shall be ferrous. Supports for copper pipes shall be non-ferrous and chromium plated where chromium plated pipe is specified. Brackets or supports shall be set out so that they not obstruct the access to valves, flanges or other fittings requiring maintenance.

Supports for Steel Pipe-Works:
All pipe openings through walls, partitions and slabs are to have sleeves having an interval diameter at least 1’ larger than the outside diameter of the pipe or of the insulation passing through the sleeve. Pipes passing through external block work or concrete shall be provided with sleeves of galvanized standard weight steel pipe flush with walls and ceilings and extending one inch above finished floors. Pipes passing through internal partitions shall be provided with sleeves of gauge 22 galvanized sheet steel made flush with finished wall surfaces.

2.7.5 Flashing Sleeves

Flashing sleeves are to be provided where pipes pass through waterproof membranes. Flashing sleeves details are to be submitted to the Engineer for approval but generally they shall be provided with an integral flange set into the membrane. The associated pipe shall also have a flange and shield which shall extend beyond the insert and be sealed with approved mastic.
2.7.6 **Pipe Insulation Protection Saddles**
Insulation shields shall be used to protect the insulation on all pipes. Insulation protection saddles shall be welded to insulated hot pipes at roller supports. Wherever fiber-glass pipe insulation is installed, alternative high density insulation of equal thickness shall be installed in lieu thereof. Where hangers and insulation shields are installed the insulation shields shall bear only an insulation material which is of such density that it will not compress, crush or deform. Saddles shall consist of gauge 10 galvanized steel plates. The plate shall be curved to fit the contour of the insulation and shall cover the lower 180 deg. of the surface. Saddles shall be secure to the insulation by means of steel bands.

2.7.7 **Strainers**
Approved “self-cleaning” strainers shall be fitted in the section line of each pump and at the inlet connections to each feeder and make-up connections, and each automatic control valve of all apparatus of an automatic character, whose proper functioning would be interfered with by dirt on the seat or by scoring of the seat. All strainers shall be suitable for pressures as stipulated for the system concerned and are to be inspected and pressure tested at the works. All strainers shall be cast iron or bronze bodied of ample strength for the pressure to which they shall be subjected with suitable flanges or tapping to connect with the piping they serve. Strainers basket screens shall be stainless steel and shall be of ample strength to prevent collapsing the basket under shock loading. Perforations shall be in accordance with the following table:

<table>
<thead>
<tr>
<th>Perforation Size</th>
<th>Number of Perforation per sq. cm.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 45 mm pipe</td>
<td>0.5 mm</td>
</tr>
<tr>
<td>45 mm to 100 mm pipe</td>
<td>1.0 mm</td>
</tr>
<tr>
<td>100 mm and above</td>
<td>3.0 mm</td>
</tr>
</tbody>
</table>

Each water strainer shall be provided with an approved valved dirt blow-out connection suitably piped to the nearest floor drain.

2.7.8 **Automatic Air Vents**
Wherever possible, all water pipe work system is to have open venting. At all high points in the system where this is not possible an automatic air vent shall be fitted and connected to the nearest drain. Air vents shall be of the float type. Sizes and working pressures shall be as indicated on the schedule, and/or in the bill of quantities. They shall be fitted with a suitable sized gate type lock shield valve.

2.7.9 **Valves**
Shut-off valves and balancing valves.
Gate valves shall be used for shut-off purposes and globe valves shall be used for balancing purposes. All valves shall be designed for packing under pressure when fully open. Shut-off valves shall be installed in both sides of all equipment.
Regulating valves shall be installed where indicated on the drawings and shall be of the Hattersley type P1373EC pattern or equal for screwed fitting or type 4733DR pattern or equal for flanged fitting.

2.7.10 **Pipe work Underground Protection**
Where pipe work is to be run underground it shall be wrapped with Denso tape. Pipe work shall be covered so that the tape overlaps to ensure two thicknesses of tape along the total length.

2.7.11 **Thermometers**
Supply and install all thermometers as shown on the drawings and wherever specified in this section of specifications.
Thermometers shall be of the bulb, mercury type 10” long with immersed bulb and brass protective shield. Graduations shall be on a white background in °C and °F.
2.7.12 **Pressure Gauges**
Supply and install all pressure gauges as shown on the drawings and wherever specified in this section of specifications. Pressure gauges shall be of the bourdon type 4” diameter with protective glass and stop pressure gauge cock. Graduations shall be in psi and kg/cm².

2.7.13 **Motorized 3-way Valve**
Valves 2” and smaller shall be bronze body screwed ends. Valves 2.5” and larger shall be cast iron with machine flanged connections. The valve spindle shall be of stainless steel, the profiled plug of brass, designed for metal to metal seating and for low noise operation. Valves shall be rated for 10bar maximum pressure and 40 to 250°F temperature range. Valves shall be supplied with reversible synchronous motors enclosed in die-cast aluminum housing.

2.7.14 **Union and Flanges**
Shall be provided on both sides of each piece of equipment. Also when required to facilitate removal of valve for repair.
Union shall be provided for all piping 2” and smaller. Flanges shall be provided for all piping 2.5” and larger.

2.7.15 **Cleaning of pipe**
During constructions, the contractor shall properly cap all lines so as to prevent the entrance of sand, dirt, etc. All pipe, fittings, valve etc. shall be cleaned of grease, dirt, scale, and foreign material before installation. Before turning the project over to the owner prior to start-up of any mechanical equipment, all piping system shall be thoroughly cleaned following the hereinafter specified instructions. Piping shall be cleaned by operating system at normal operating pressure approximately 48 hours. At the end of the 48 hours period, contractor shall clean all strainers by removing baskets and flushing with clean water; Blowing down thru strainer blow down valve will not be acceptable.

2.7.16 **Testing**
The piping system shall be tested by accepted method and under 150 psi hydrostatic pressure. Test shall be maintained under inspection by consulting engineer for period of not less than 24 hours.
If leaks develop test shall be repeated after leaks are corrected. No part of piping system shall be covered or concealed until it has been tested inspected and approved by engineer.

2.7.17 **Balancing of piping systems**
After installation is complete, entire hot water heating system shall be balanced to provide g.p.m. flows and temperature differentials across coils, pump, and heat exchangers to agree with valves specified and shown on drawings.

2.8 **Intake and Exhaust Louvers, IL,EL.**
All fresh air inlet and exhaust air outlets are to be fitted with aluminum wire mesh bird and anti-vermin screens. Louvers are to be constructed from extruded aluminum to a design to prevent ingress of rain and are to be approved by the Engineer. All louvers are to be supplied and fitted by the contractor unless otherwise specified or indicated on the drawings.

2.9 **Grilles, Registers & Diffusers**
- **General**
  Before placing orders for these items, the contractor shall check that all items to be supplied by the manufacturer comply for throw, drop and noise, with capacities as indicated on the drawings. All outlets shall be specifically selected for their particular application and designed for quiet operation.
All items are to be approved by the Engineer. All grilles, registers and diffusers shall be of construction and finish as indicated in the bill. All devices shall have substantial approved gaskets to completely prevent streaking on walls due to leakage.

• **Sidewall Grilles (S.G.) (R.G.)**
  All side wall supply and return outlets shall be of the double deflection type, having vertical front bars and horizontal back bars and fitted with key operated opposed blade dampers.

• **Diffusers (R.D) (S.D)**
  Diffusers shall be furnished with equalizing grids as furnished by the diffuser manufacturer. Volume control dampers for these outlets shall be accessible through the outlets from below the ceiling and shall maintain their setting when adjusted. Each diffuser shall be provided with sponge rubber or felt gasket and angle ring or frame for securing to ductwork. Return diffusers (R.D) shall be identical to supply diffusers.

• **Linear Grilles**
  Type RG is for return & exhaust grilles of the linear type constructed from extruded aluminum sections, framed without flange and entirely suitable for ceiling mounting. Grilles to have fixed profiled blades 6 mm wide at 13 mm centers, set at 0 degree angle.

• **Air Openings Wooden Frames**
  Timber frames shall be constructed of continuous clean length of timber planed on all sides and free from shakes and knots, visibly, treated against vermin and insect attack.

• **Installation of Linear Grilles**
  Where specified in the schedules and bill, certain linear grilles will need to be supplied to a normal oversize length. These grilles will then need to be cut to length on site by the contractor to a precise measurement to suit the detail. Grilles are to be cut with a machine saw using a jig to ensure a right angle. The cut is to be fine to leave no rough edge nor damage to the grille face. The cut edge is to be treated as necessary for appearance and protection to obtain the same coloring, appearance and life as the finish on the grille face. Spare sections of linear grille are to be provided with the grille to allow replacement of spoiled grilles.

• **Arrangement**
  Where specified in the schedule and bill, some linear grilles will need to be supplied with opposed blade damper made in set lengths to duct connections behind the grille.

2.10 **Fresh Air Intake & Outlet Louvers**

• **General**
  All fresh air inlet and exhaust air outlets shall be fitted with aluminum mesh bird and anti- vermin screens.

• **Fresh Air Louvers (F.A.L)**
  Fresh air louvers shall be extruded aluminum with an overall louvers depth as indicated on drawings. The louvers blade extrusion shall be of a design to prevent ingress of rain and is to be approved by the Engineer.

2.11 **Air Distribution**
  The contractor shall supply and install all sheet metal work indicated on the drawing together with all accessories such as canvass connection to unit volume damper etc…
  These specifications will supply for all duct and air outlets in this project either for air-conditioning or ventilation.

A. **Duct Work**
  All duct work shall be constructed from galvanized sheet metal steel in full accordance with I.H.V.E guide, ASHREA standard or equal in general ducting shall conform to following table.
**Rectangular sheet metal duct**

<table>
<thead>
<tr>
<th>Duct size</th>
<th>Gauge</th>
<th>Thickness</th>
<th>Recommended Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 12&quot;</td>
<td>26</td>
<td>0.55 mm</td>
<td>Pocket slip or bar-S slip spaced not more than eight feet apart</td>
</tr>
<tr>
<td>13&quot; - 30'</td>
<td>24</td>
<td>0.7 mm</td>
<td>Pocket slip or bar-S slip spaced not more than four feet apart.</td>
</tr>
<tr>
<td>31&quot; - 60&quot;</td>
<td>22</td>
<td>0.86 mm</td>
<td>As before</td>
</tr>
<tr>
<td>61&quot; - 90&quot;</td>
<td>20</td>
<td>1 mm</td>
<td>Reinforced pocket slip or reinforced Bar-S spaced not more than four feet apart.</td>
</tr>
<tr>
<td>1 1/2 x 1 1/2&quot; x 1/8&quot; diagonal angle reinforcing.</td>
<td></td>
<td></td>
<td>As before.</td>
</tr>
<tr>
<td>91&quot; and up</td>
<td>18</td>
<td>1.3 mm</td>
<td></td>
</tr>
</tbody>
</table>

Duct will be insulated or lining as indicated in drawing with 1" crok or fiberglass and protected with silver hand wired paper for air conditioning duct. Duct for ventilation will not be insulated.

Duct will be hanged and supported on iron angles which will be painted with anti-corrosion paint or metallic supports.

Duct transformations are used to change the shape of duct or to increase or decrease the duct area.

The recommended slope of the transformation is 1" in 7" when reducing the duct area where it is impossible to maintain this slope it may be increased to a maximum of 1" in 4". When the duct area is increased the slope is not to exceed 1" in 7", when the shape of rectangular duct is changed but the cross-sectional area remains the same slope of 1" in 7" is recommended if this slope cannot be maintained a maximum slope of 1" in 4".

Elbow must be full radius elbow with throat radius equal to 3/4 of duct dimension in direction of the turn as shown in detail drawing.

If it is impossible to use full radius elbow a short radius vaned elbow as shown in detail drawing must be used.

Take-offs are constructed according to detail drawing. Each take-off supply by splitter damper for proper air quantity supply. The recommended take off used full radius elbow.

Duct sizes shown on drawings are sheet metal sizes and allowance has been made for installation of lining where applicable.

Duct less than 15" in depth may be reinforced with angles on top and bottom only. The above reinforcing of duct and housings in minimum and addition reinforcing shall be installed where directed by the supervising engineer, and where it is necessary to eliminate excessive movement and vibration. All supply ducts shall be made air tight against 3" W.G. air pressure and should the supply ducts appear to leak excessively, then the contractor will be required to apply in air pressure test to determine the tightness of the duct work.

All other duct work shall be made practically air tight. All openings, corners, and joints of all duct work shall be sealed or soldered as required to prevent air leakage. Drive slip joints shall be sealed tight with rubber base mastic of approved manufacturer. Mastic shall be applied to the duct and drive slip before installation of the drive slip. Duct shall be supported unless otherwise detailed with 3/16" rods or # 16 gauge galvanized strap hangers spaced not over 10" on both sides of duct attached to bottom of duct and attached to construction with inserts, toggle bolts or other approved means. All vertical ducts shall be adequately braced to wall or construction and shall be supported with angle frames where they pass through floor.

The sheet metal contractor shall cooperate with all other contractors, so that all sheet metal work duct clear pipes, conduit hangers supports and other obstructions sheet metal work shall include the setting of all automatic dampers furnished under heading of temperature control work. Duct connection to air handling equipment and where noted elsewhere on plans, shall be made with fire resistant water proof and mildew resistant canvass connection to shall be not less than 4" long, shall have suitable metal coller from each end, shall be made with at least one inch slack in material to prevent transmission of vibration.

Lining shall be smoothly and permanently adhered to inside of duct with a heavy spray coat.
of adhesive applied to 100% of duct surface. Lining on tops of horizontal ducts which exceed 12" width and lining on side of duct which exceed 16" in height shall be additionally secured with welding pins, spaced not over 15" o.c. Washers on pins shall be carefully applied so that surface of lining is not depressed. Lining in duct which is formed with one piece of metal for all four sides may be applied before sheet metal is formed. Lining in ducts which are formed of two or more pieces shall be applied in cut-to-fit pieces after sheet metal is formed. Leading edge of ginning at joints shall be coated with adhesive. The interior of all ducts and boats that can be seen through grills shall be coated with dead black paint applied to clean surface. Sheet metal work shall include the adjustable and balancing of air supply and exhaust systems. Fan speed shall be adjusted for proper air delivery in according with ratings furnished by the fan manufacturer. Following first adjustment of fan speeds, air supply system shall be adjusted to multiple air delivery and temperature readings through out air conditioned and ventilated space so as to provide reasonably uniform temperature conditions. If air supply is not sufficient to provide air circulation as required contract shall readjust air system, including dampers for uniform temperature, conditions throughout. Exhaust system shall be adjusted for exhaust of air quantity as shown on plans.

B. Flexible duct
The contractor shall supply and install a range of fiberglass insulation flexible duct such as DEC-Acoustic insulated Sonodec type 25 & type 50. Flexible duct fabricated of galvanized steel wire helix permanently bonded to a vapor barrier Aluminum film enclosed in 1 1/2" thickness fiberglass blanket and covered with a vapor barrier film. Joints shall be made in accordance with manufacturer's instructions. Connection and take-off for flexible duct must be done by galvanized sheet metal fitting.

C. Protection and Cleaning
- During construction, cover all open ends of ductwork with one layer of canvas.
- Remove all foreign materials and clean the duct inside and outside.
- Clean ducts before operating fans and filters. Never operate fans unless filters are installed.
- Operate the fan and thoroughly blow out the interior surfaces of the duct work.
- After tests, wash cleanable filters and replace renewable media.

D. Hangers for Ducts
Supply and install steel work necessary for the support of the ductwork. Hangers shall be spaces not more than 3000mm apart and at changes of direction. Types and construction of hangers shall be as detailed on the drawings and in compliance with SMACNA recommendations.

E. Duct hanger
Duct hanger shall be of two types:
1. U shaped flat steel bar hanger for ducts with greatest dimension 20”
2. Two threaded steel bars Ø 12mm and support steel angle for ducts with greatest dimension 20” and above.
Hanger shall be spaced as follows:

<table>
<thead>
<tr>
<th>Duct Size</th>
<th>Maximum Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 30”</td>
<td>3 feet</td>
</tr>
<tr>
<td>31” to 54”</td>
<td>6 feet</td>
</tr>
<tr>
<td>55” to 120’</td>
<td>4 feet</td>
</tr>
</tbody>
</table>

F. Volume Dampers
- Supply and install volume dampers with locking levers and quadrants, indicating their position in main ducts and in all branch ducts supplying three (3) or more air outlets, in all fresh air intakes and where shown on the Drawings.
- Volume dampers shall be of the butterfly type for ducts 15” (380 mm) in depth and lower, and multiple opposed blade type for ducts above 15” (380 mm) in depth. Maximum blade size shall be 48” x 10” (1220 x 250 mm). For ducts larger than 48”(1220 mm), multiple frame
sections shall be used. Blades shall not be less than 18 gauge. Duct shall be stiffened at damper location. Volume dampers for circular ducts shall be of the multiple opposed blade type fitted in a square section.

- Upon completion of the ductwork, dampers shall be adjusted and set to deliver the amounts of air indicated on the Drawings.

G. Fire Dampers
- Fire dampers shall be provided on all duct branches which pierce fireproof floors, walls, shafts, ceilings and as required in accordance with NFPA SECTION NO. 90A.
- Assemblies shall be complete with damper blades, fusible links, linkage, and stops.
- Dampers shall be of steel plate, mounted to turn freely in a galvanized steel plate frame inserted in the duct.
- Dampers shall be proportioned and weighed to close at once if released from a link with spring catches and shall stay closed until manually reset.
- Standard fusible-links, normally holding dampers open, but releasing them upon contact with fire at temperature of 158 °F (70 °C), shall be provided.
- Dampers and frames shall have suitable peep holes.
- Damper blades shall be constructed of insulating material with galvanized steel plates cover all around to form a damper of the required fire rating.
- Single blade dampers, up to 18” (450 mm) in any direction, shall have a plate 1.6 mm thick. From 19” to 36” (460 to 900 mm) in any direction, plate shall be 2.75 mm thick.
- Multiple blade dampers shall consist of linked blades of not less than 1.6 mm thick steel plate. Maximum blade dimensions shall be 6” x 24” (150 x 610 mm).

H. Flexible Connections
- Flexible connections of approved flame retardant fabric to prevent the transmission of vibration through the ducts shall be installed on both the supply and return sides of all fans and ventilating units for a maximum length of 250mm and a minimum of 100mm. in the direction of the flow.
- Cloth used for flexible connections shall be of proper weight and strength for the service required, and shall be properly fitted to render it relatively tight.
- Neoprene laminated asbestos fabric; with neoprene facing on interior surface shall be used for ducts handling other than clean dry air.

I- Belt Guards
- Guards shall be provided for all belt-driven units.
- Guards shall be made to enclose both pulleys and belts on exposed sides and shall be constructed of galvanized steel top and bottom with perforated or expanded metal front Pittsburgh-locked into the rim.
- The entire assembly shall be rigidly supported.
- Provision shall be made for accessibility of all points drilled to receive tachometer.
- Provide coupling guards on direct-connected units.
- Guards shall be designed for easy removal for service and shall comply with Underwriters’ Safety Requirements.

J- Noise Attenuation
The Contractor shall supply and fix acoustic insulation and noise attenuator units where necessary to reduce the airborne noise transmission through the distribution duct system; so that the specified noise criteria levels are satisfied.

- Attenuation Unites
The attenuator units shall be inserted in the ducts where they pass through the mechanical room walls, the gap between the wall and attenuator being packed with felt to form an air tight seal. However where this is not possible, the attenuator shall be fitted in the duct between the fan and the mechanical room wall with the duct between the silencer and the wall acoustically lagged to prevent noise re-entry. Attenuators shall consist of attenuator splitters which are assembled in one attenuator casing. Splitter case shall be made from galvanized sheet steel: absorption material moisture repellent and abrasion proof up to
approx. 3600 fpm. (18 m/s) air velocity, control plates on surface of splitters is made from galvanized steel sheet.

Sound attenuator casing shall be made from galvanized sheet steel, with pre-drilling angle flanges.

Attenuators or splitters of large cross section or length can be manufactured in modular section as required for ease of site handling.

- Internal Acoustic Lining of Ducts
- Furnish and install duct lining wherever shown on Drawings.
- Where it is possible to achieve the required attenuation by lining the interior of duct runs, this may be accomplished by applying one inch thick lining to the inside of the ducts.
- Lining for rectangular ducts shall be semi-rigid fibrous glass blanket and for round ducts shall be flexible fibrous glass blanket, both with special surface treatment and for apparatus casings, large plenums, and masonry air shafts shall be rigid coated fibrous glass board.
- Acoustic insulation shall be suited to the atmosphere in which it is to operate, and shall be incombustible or self-extinguishing non-flame spread grade, vermin proof and adequately fixed to ducting or mechanical room walls. Liner density shall be 3 lbs. per cu. ft and shall comply with NFPA requirements.
- Duct liners shall be applied with both mechanical fasteners and an adhesive. Adhesives must be both water and fire resistant.
- Mechanical fasteners could be either of the welded pin or impact pin types. The length of each pin shall be enough to accommodate the specified liner thickness. Washers on top of the pins shall retain the liner.

### 2.12 Insulation

#### 2.12.1 General

Insulating materials required for piping, mechanical equipment, ductwork, etc. shall be furnished and installed under this section of the specifications. Insulation shall be installed in a smooth, clean, workmanlike manner and joints shall be tight and finished smooth. All surfaces to be insulated shall be dry and free from loose scale, dirt, oil or water when insulation is applied. Insulation shall be applied in such manner that there will be no air circulation within the insulation or between the insulation and the surface to which it is applied. Surfaces imperfections in the insulation such as clipped edges, small joints or cracks and small voids or holes not over 25 mm square shall be filled with like insulating material. Where a vapor barrier is fixed on site it shall be fixed in such a manner as to obviate the possibility of moisture penetration. It shall be fixed where required by means of an approved type bituminous compound or approved adhesive. No piping, duct or equipment shall be insulated until tested and approved for tightness. Insulation for all services shall be continued through sleeves. The insulation on exposed risers shall extend through the floor. Insulation is to be applied where indicated on drawings or called for in these specifications. The type of insulation used for the various services and equipment is to be as detailed on drawings, schedule and bills, together with thicknesses, K factor and other properties.

#### 2.13 Piping Insulation

Where piping is to be insulated requiring a vapor barrier, insulation is to be used unless otherwise stated on bill of quantities, specification and drawings. Insulation is to be rigid section 13 mm armoflex tubes to conform to the pipe with a factory applied flame retardant aluminum foil vapor jacket. Longitudinal joints shall be sealed with an overlap of the vapor seal firmly fixed with an approved adhesive.

#### 2.14 Equipment Insulation

Insulation which is applied to equipment having renewable heads and/or access plates shall be applied in a manner which will permit easy removal and replacement of the insulation. In general this shall be accomplished by encasing the insulation in sheet metal boxes which
shall bebolted together. Pumps of chilled services are to have insulation (as for the related piping) on the casing, vapor sealed, and finished with Armoflex sheeting or equal and approved. Insulation shall be fixed with an approved adhesive on a clean surface.

2.15 **Duct Insulation**

Duct will be insulated with 1 1/2” thick glass fiber flexible blanket type for concealed insulation with a density not less than 1 lb. / cu. t. and a foil scrim-Kraft laminated jacket. Install insulation with fire retardant adhesive applied to 100% of surface and insulation wrapped around duct with 2” over lapping tab formed by stripping away insulation to form longitudinal joint. Longitudinal joint shall be located on top surface of duct or in most inconspicuous location and shall be taped with vapor barrier tape to match facing and applied with vapor barrier adhesive. Exposed duct with outside insulation shall be covered by .0.6sheet metal jacket J.

2.16 **Noise Attenuation**

The Contractor shall supply and fix acoustic insulation and noise attenuator units where necessary to reduce the air borne noise transmission through the distribution duct system; so that the specified noise criteria levels are satisfied.

Attenuation Unites room walls, the gap between the wall and attenuator being packed with felt to form an air tight seal. However where this is not possible, the attenuator shall be fitted in the duct between the fan and the mechanical room wall with the duct between the silencer and the wall acoustically lagged to prevent noise re-entry.

Attenuators shall consist of attenuator splitters which are assembled in one attenuator casing. Splitter case shall be made from galvanized sheet steel: absorption material moisture repellent and abrasion proof up to approx. 3600 fpm. (18 m/s) air velocity, control plates on surface of splitters is made from galvanized steel sheet.

Sound attenuator casing shall be made from galvanized sheet steel, with pre-drilling angle flanges. Attenuators or splitters of large cross section or length can be manufactured in modular section as required for ease of site handling.

Internal Acoustic Lining of Ducts Furnish and install duct lining wherever shown on Drawings. Where it is possible to achieve the required attenuation by lining the interior of duct runs, this may be accomplished by applying one inch thick lining to the inside of the ducts.

Lining for rectangular ducts shall be semi-rigid fibrous glass blanket and for round ducts shall be flexible fibrous glass blanket, both with special surface treatment and for apparatus casings, large plenums, and masonry air shafts shall be rigid coated fibrous glass board.

Acoustic insulation shall be suited to the atmosphere in which it is to operate, and shall be incombustible or self-extinguishing non-flame spread grade, vermin proof and adequately fixed to ducting or mechanical room walls. Liner density shall be 3 lbs. per cu. ft and shall comply with NFPA requirements.

Duct lines shall be applied with both mechanical fasteners and an adhesive. Adhesives must be both water and fire resistant.

Mechanical fasteners could be either of the welded pin or impact pin types. The length of each pin shall be enough to accommodate the specified liner thickness. Washers on top of the pins shall retain the liner.

2.17 **Duct Insulation**

2.17.1 **Package Roof Tops Reversible Air Conditioning unit**

The contractor shall supply and install as indicated on drawings a range of approved types such as Carrier, Train or equivalent Package roof tops air conditions unit of capacity and ratings as specified in drawing where ever required.

a. **Quite Operation**

   **General**
   - Units shall be basically constructed and engineered with noise reduction as a first consideration (low noise mounted fans are used, fiber glass insulation for evaporator section and compressors are mounted on vibration
isolators). Units should be factory assembled and pre-charged, with single point electrical connection. On arrival to the job site they are ready to be lifted to their operation position through the lifting supports available on the unites.

- Units shall be microprocessor controlled air-cooled package with hermetically sealed scroll compressor(s) or hermetic piston compressor(s), thermostatic expansion valve, evaporator and condenser coils, fans and controls.
- Units shall be designed, engineered, and manufactured for outdoor installation.
- Units shall be shipped in a single piece from factory.
- Units shall be factory assembled, piped, wired, tested and fully charged with R407-c and compressor oil.
- The units shall incorporate all safety and operating controls and equipped with single or multiple hermetic scroll/piston compressors with fully independent refrigeration circuits.
- The microprocessor controls the full refrigeration cycle (compressors and fans).
- Fully identified tags and stickers shall be available on the units to indicate for any cautions and aid in unit service.
- Units shall be run tested at factory and all parameters shall be verified before shipment.
- Fully laminated wiring diagrams for long lasting life shall be shipped with each unit inside a special metal pocket in the electrical panel door.
- A carved-on painted aluminum sheet unit nameplate with full data shall be riveted on the unit near the unit electrical panel.

**Quality Assurance**

- Units shall be manufactured in an ISO 9001-2000 and ISO 14001-1996 certified facility.
- Units are manufactured in a facility registered to EMC certificate through TUV product service emphasizes special product properties such as safety, durability and quality.
- To assure quality all units approved by CE (European Committee).
- The unit construction shall be in compliance with applicable requirements of safety standards in ASHRAE 15 safety code.
- The units shall have a minimum energy efficiency ratio as per ASHRAE 90.1 standard.
- Each unit shall be factory run tested at full load conditions. Test results for all units are available up on request.

**Unit Cabinet**

- Units framework shall be constructed of 14-gauge G90 galvanized steel.
- Cabinet shall be coated with electrostatic polyester powder coat, oven baked which can withstand 500 hours salt spray test in accordance with ASTM B117 standard.

**Insulation**

All units are internally lined with 1.0 inch thick fiberglass insulation for the coil and fan section (evaporator side only).

**Unit Base**

- Base frame is constructed from heavy gauge galvanized C-channel steel.
- The base is constructed with full supporting cross members welded all around to increase strength, rigidity and minimize deflections.
- Heavy duty mounting chassis for the whole unit with lifting lugs are used for unit loading, unloading and handling.
- The unit base shall be coated twice by epoxy paint.

**Condenser Fans**
- Condenser fans shall be of the direct driven type with axial (propeller) blade, up-ward discharge.
- Fan blades are made from coated steel or aluminum, for maximum corrosion resistance, and are statically and dynamically balanced.
- Condenser fans are equipped with heavy duty wire guards made from steel with electrostatic polyester powder coat, oven baked.
- All fans are selected for optimum efficiency and maximum sound power reduction.

**Condenser Fan Motor**
- Motors shall be high efficiency, squirrel cage induction type, totally enclosed fan cooled (TEFC), with permanently lubricated bearing and three phase power supply.
- Motors shall have a IEC standard frame, a class F motor insulation, and a 6-pole motor with a maximum motor speed of 1,100 rpm for (60 Hz) units and 900 rpm for (50 Hz) units.
- Motors shall have internal thermal motor protection.
- Motors could be equipped with factory mounted external overload relay.

**Belt Drive Evaporator Fan**
- Forward curved centrifugal DWDI [Double Width Double Inlet] type.
- Fans are designed for maximum efficiency and uniform air distribution.
- Fans are V-belt driven with variable pitch pulley (for fan motors with 5.5 kW and less only).
- All fans are statically and dynamically balanced to ensure quiet operation and optimal performance.

**Evaporator Fan Motor**
- Motors are of the totally enclosed induction type.
- Fans motors are of the four pole and highly efficient, induction type motors, totally enclosed air-over.
- Fan/motor assembly placed on a floating base with a flexible connection at the fan/casing interface.
- The base itself is mounted on rubber in shear vibration isolators to eliminate noise and vibration transmission to buildings.

**Scroll Compressor**
- The scroll compressor shall be hermetically sealed scroll compressor, refrigerant gas cooled with crankcase heater, built-in check valve, and built-in safety pressure relief valve.
- Compressor motor is protected by internal thermal protection (in each phase).
- Suction gas cooled compressor motor winding.
- The compressor shall be mounted on anti-vibration compressor mounting (rubber -in -shear) so as to reduce the transmission of body radiated noise.
- Rain-tight terminal box.
- Direct-on-line starting.
- The compressor shall be with high performance and efficiency, low sound; so as to match all other Petra products’ reliability and efficiency.
Evaporator and condenser coils
- Condenser coil shall be constructed from aluminum fins mechanically expanded into seamless copper tubes.
- Fins shall be made from aluminum alloy. The fins shall be plate type; die formed with sinusoidal surface and rippled edges. Each fin shall have a formed self-spacing collar covering the copper tube completely.
- Tubes shall be seamless copper and manufactured according to ASTM B-68 and B-75. Headers shall be made from heavy wall type L hard copper pipes.
- Coils casing shall be made from 16 gauge galvanized steel with end plate having a die-formed extruded tube holes for maximum tube protection and support.
- All coils are leak tested under water at 450-psi.
- Condenser side could have an optional complete wire mesh all around its perimeter.

Filters
All models are provided with 1.0inch thick aluminum flat filter (as standard features). Other filters are available upon request.

Drain Pan
All unites are provided with a drain pan having a drain connection from one side. The drain pan is insulted on the sides and underside to prevent condensation.

Electrical Panel
The electrical panel shall consist of two sides:
- I. Power side: shall have the following components:
  - Power circuit fuse or circuit breaker in each phase for each compressor
  - Power circuit fuse or circuit breaker in each phase for condenser fan motors.
  - Condenser fan motor and compressor motor starting contactors.
  - Voltage monitor controller (phase failure relay):
    - The voltage monitor controller monitors the main incoming power supply to the unit. It provides protection from single phasing, under voltage, over voltage, phase voltage imbalance and non-phase sequence.
      - Single points power connection.
      - External overload thermal motor protector for condenser or/and compressor motors (Optional).
- II. Control side: shall have the following components:
  - On/Off switch for each compressor.
  - Control circuits fuse or circuit breaker to protect the control circuit from short circuit.
  - Control transformer sized to supply the needs of the control circuit, sourcing power from the main unit power connection.
  - Control terminal strip for easy connection with electrical board and easy field connection.
  - Microprocessor controller for full management at unit operation and safety with an attractive user-friendly interface keypad.

Electrical Panel
- Control voltage is 220 Volt for the components outside electrical panel, crank case heater, liquid solenoid valve and compressor motor
protector (all these components are located outside electrical panel).

- Control and power panels include the across the line (direct on line) starting for the compressors.
- Wiring diagram attached to each unit figures out the correct power and control connection including the controller.
- On the attached wiring diagram there could be some free terminals (optional) which intended to be connected in the field or for remote connection and indication such as:
  - Remote switch terminals: these two terminals can be used for remote control (turning on/off) of the unit and also can be connected to the B.M.S; these terminals must be kept jumpered if they are not intended to be used.
  - General alarm terminals: These two terminals can be used for remote fault indication that also can be used with the BM System to indicate unit faults. These terminals are potential free terminals.
    - Unit shall be completely factory power and control wired, installed and tested.

### Control

- The control system shall include the following functions:
  - Controlling units in both cooling and heat pump modes.
  - Temperature control based on return air as standard.
  - Different set-point modes: unoccupied, comfort and night time set-point mode.
  - Remote (ON/OFF) system selection.
  - Coded alarm management with an audible alarm.
  - Suitable identified symbols to display data.
  - Temperature readings °C.
  - Short cycling protection for compressors (time delay).
  - Smart lead-lag operation for compressors.
  - Head pressure control by the simple ON/OFF condenser fan motor according to ambient temperature.
  - Auto restart after power failure: The program and set parameters are permanently saved in a flash memory, preventing data loss in the case of power failure (back up battery or auxiliary power for maintaining program memory is not required.)
  - Activation of electric heaters.
  - Humidification and dehumidification functions.
  - Defrost regulation.
  - External set-point reset.
  - Daily and weekly start-stop schedules management accommodating weekends and holidays.
  - Visible full text alarm message.
  - Alarm history: The safety shutdowns are date and time stamped with system temperatures, currents and pressures recorded.
  - Power demand limit for the unit.
  - Head pressure control by the simple ON/OFF condenser fan motor according to ambient temperature (standard). Or by providing an analog signal for speed controller).
  - Automatic pump down at each compressor stop.
  - Super heat controlling.
  - Controlling activation of dampers.
  - Economizer control.
  - Enthalpy control.

The unit shall have the following temperature sensors:
- Return air temp. sensor: intended for controlling the return
air temperature (set-point).
- Outside ambient temp. Sensor: intended for controlling the low ambient kit protection function.

In addition to the above sensors, the advanced control system shall provide the following extras:
- Supply air temp. sensor: intended for monitoring the supply air temperature. This sensor can also be intended for controlling the optional anti-freeze protection or function.
- Discharge temp. Sensor: monitoring discharge temp. And controlling the operation of liquid injection solenoid valve in addition to high limit prevention and cutouts protections.
- Suction temp. Sensor: intended for monitoring suction temp. and superheat for each compressor in addition to high/low limits cutouts protections.
- Inside and Outside humidity sensors: enthalpy, Humidity controls.

The unit shall have the following refrigerant pressure devices (in each refrigerant circuit):
- Low-pressure switch (L.P.S) (auto-reset): located at the suction line for safety low pressure protection.
- High-pressure switch (H.P.S) (manual reset): located at the discharge line for safety high-pressure protection.
- Thermostatic expansion valve: incorporated to maintain the correct evaporating superheat and suction pressures required for optimized system efficiency.

The control system provides the following easily accessible readings and measurements:
- Return air temperature.
- Ambient temperature.
- Unit operating mode.
- Fan operating mode.
- Set-point override.
- Number of compressor/supply fan operating hours.
- Status of all inputs.
- Status of all outputs.

In addition to all of the above measurements, the advanced control system shall provide the following extras:
- Number of compressor/supply fan operating hours.
- Number of compressor starts.
- Supply air temperature.
- Return air temperature.
- Ambient temperature.
- Super heat reading.
- Discharge or and suction pressure readings.
- Status of all inputs.
- Status of all outputs.

The control system provides the following alarms and safeties:
- Low suction pressure.
- High discharge pressure.
- Low supply air temperature (Freeze protection).
- Defrost alarm (signaling-only alarm).
- Phase loss protection.
- Motor temperature (High motor temperature or motor fault).
- Dirty filter.
- Probe fault (signaling-only alarm).
- Exceeding the number of operating hours for compressor / supply fan (signaling-only alarm).

In addition to the above alarms and safeties, the advanced control system shall provide the following extras:
- Low supply air temperature (Freeze protection).
- Phase loss protection.
- Motor temperature (High motor temperature or motor fault).
- Dirty filter.
- Probe fault (signaling-only alarm).

2.18 Split Unit Heat pump Air Condition Unit
Split type air-conditioning unit, reversible cycle (heat pump), high wall mounted type indoor unit, air discharge directions, with adjustable air emitting the wall unit (indoor unit) depth not to exceed 35 cm. remote controller:
All operation of the remote control unit to be push button system. Each switch has a lamp which is illuminated when switch is pushed. The controller to include:
1) Three speed fan selector
2) Pre-heater/defrost lamp
3) Indication lamp for each switch
4) Operation On/Off switch
5) Thermostat control heat-cool

The outdoor unit includes the condenser, condenser fan and the rotary type compressor, and all relays and safety switch as following:
- Reversing valve
- Defrost thermostat
- Relay
- Transformer
- Thermostat
- Varister
- Bimetal thermostat for condenser fan
- Over current relay for compressor contactor
- Magnetic contactor for compressor
- High pressure switch
- Crankcase heater
- Capacitors for fan
- Safety fuses
- Terminal board for main circuit
- Terminal board for control circuit

The Indoor unit:-
- Internal thermostat for fan motor
- Fan motor
- Capacitor for motor fan
- Drain up motor
- Earth terminal
- Float switch for line cut
- Transformer
- Terminal board for control circuit
- Terminal board for main circuit
- Relay for IC control
- Varistor
- Thermistor (indoor temperature)
- Thermistor (indoor heat exchanger)
3. General

3.1 Scope of work
The contractor shall furnish all labor, materials, equipment, tools, apparatus; services and temporary work to provide complete the several plumbing and drainage systems all in perfect working order. This work shall include but not be limited to the following:
- Sanitary fixtures.
- Water supply systems including cold water, soft water and hot water services.
- Soil, waste, and ventilation systems.
- Rain water services.
- External gravity sewer network.
- Testing of all piping systems and equipment and other devices to demonstrate that the entire installations are in perfect working order.
- Builders’ work: as required.

All fixtures and materials shall be brand new bearing stamped ratings as required and must be approved by the Engineer prior to installation.

The foregoing sub-paragraphs are not intended to itemize all works required by this section of the specifications and are only for the purpose of outlining the extent of work for the guidance of tenders.

3.2 General Description of The Work
The sanitary works shall consist of all water supply to and water discharge from all sanitary fixtures. Water distribution to all floors is effected by roof tanks gravity pressure. Hot water is generated by means of solar heating panel and electrical heater. Drainage of all floors is discharged by gravity from individual points to risers which are interconnected to a system of manholes which will be later discharged to a public sewer system. Fire protection by portable fire extinguishers. Rain water is directly discharged to street.

3.3 Working drawings and ordering
Immediately the contractor has been awarded, the contractor shall prepare detailed working drawings showing exact position of all sanitary fixtures and position and size of all water pipe-work and drainage, soil, waste and vent piping, clearly indicating fittings proposed. These drawings, when approved by the Engineer, shall be used for ordering purposes.

3.4 Testing
a) General
The contractor shall submit to the engineer prior to the date of commencement of the tests his proposed test procedure. The procedure method and points of measurement and the method of calculation shall be approved by the engineer before any test is carried out.

The contractor shall supply skilled staff and all necessary instruments and carry out any test of any kind on a piece of equipment, apparatus part of a system or on a complete system if the engineer requests such a test for determining specified or guaranteed data, as given in the specifications.

Any damage resulting from the tests shall be repaired and/or damaged material replaced, all to the satisfaction of the engineer at the expense of contractor.

In the event of any repair or any adjustment having to be made other than normal running adjustment, the tests shall be void and shall be repeated after the adjustment or repairs have been completed. The tests shall not be made void due to circumstances
b) Water Supply Systems
All water supply piping shall be tested under hydrostatic pressure of not less than 1.5 times (8Bar) working pressure p.s.i., maintained for twelve hours. This test shall be applied to separate lengths of pipe work before final connection of equipment and appliances but after all piping is completed. Systems shall also be flushed. Test shall be completed and approved before pipes, valves and fittings have been concealed. These systems shall be subject to a water test prior to being covered and also tested for water tightness before backfilling. On any section of the pipe under test, the head of water applied shall not be less than 3.00 meters and not greater than 6.00 meters. Tests shall be maintained for 20 minutes, and any defects shall be rectified and the test reapplied to the complete satisfaction of the engineer.

c) Drainage, Soil, Waste and Ventilation System
These systems shall be subjected to a water test prior to being covered and also tested for water tightness before backfilling. On any section of the pipe under test, the head of water applied shall not be less than 3.00 meters and not greater than 6.00 meters. Tests shall be maintained for 20 minutes, and any defects shall be rectified and the test reapplied to the complete satisfaction of the engineer.

d) Final Testing
In addition to the above, final tests shall be carried out as directed by the engineer, just before final completion of the works and during the maintenance period.

3.5 Sanitary Fixtures

3.5.1 General
Supply and install all sanitary fixtures shown on the drawings and as specified in these specifications. Vitreous china fixtures shall be of the first quality with smooth glazed surfaces, free from wrap, cracks, checks, discoloration or other imperfections.

Fixtures shall be set in a neat, finished and uniform manner making the connection to all fixtures at right angles to the wall, unless otherwise directed by the engineer. Fixtures are not to be set until so directed by the Engineer.

Ample application of petroleum jelly shall be applied to all surfaces of exposed chromium plated piping, valves and fittings and stainless steel fixtures immediately after installation.

All fixtures shall be set, true, level, and finished in an approved and uniform manner.

Concealed brackets, hangers and plates shall have a shop coat of paint.

All necessary supports for fixtures shall be installed before plaster work.

All exposed piping and trim shall be chrome plated and fully protected during installation. Strap or padded wrenches shall be used on chrome pipe fittings and valves.

All exposed metal parts in toilets rooms and bathrooms shall be chromium plated and fully protected during installation.

All valves in bathrooms, toilets and kitchens shall be chrome plated recessed type.
In the selection of the sanitary fixtures and their accessories, model numbers of manufacturer’s catalogues are given. A model numbers is given to describe the type and the shape of the item requested and does not in any way limit the supply to the model listed. Any item of different make judged by the engineer to be similar in quality and manufacture will be approved. Catalogues will be available at the engineer’s office for reference. The location and disposition of all items shall be indicated on the relevant drawings.

3.5.2 **Lavatory Basins**

Each lavatory shall be white vitreous china of model wall hang and shall be complete with the following:
- Chrome plated hot and cold lever mono-block basin.
- Chrome plated ½”x3/8” angle valves for hot and cold water supply with chrome lever handles and chrome plated tube.
- Chrome plated 11/4” P-trap with clean out plug.

Glass mirror for all lavatories 50 cm width and 90 cm height.

Liquid Soap dispenser for each lavatory.

Copper screw10mm with expansion plastic wedge support, and all pipe works and accessories required for its installation, connection to water supply and drainage, supports, fixing and its satisfactory operation.

3.6 **Water Closet**

Each water closet shall be white vitreous china with P-trap of type wall hung and floor mounted and shall be complete with the following:
- White vitreous china flush tank.
- White heavy-duty solid plastic seat and cover with stainless steel check hinge of some toilet type
- Chrome plated wall fixing screws, wall support frame and gaskets.
- 4-2 Chrome plated 1/2” angle valve.
- 60cm Chrome plated flexible hose
- 6-100 cm chrome plated hose with hand spray tape.
- 7- Paper holder.
- 8- All necessary fixing and accessories required for connecting the flushing tank to main cold water line and W.C main sewage pipe.

3.7 **Showers**

Each shower shall be of glazed fire clay of size 80x80cm completed with the following:
- Wall mounted hot and cold water lever mixer with chrome plated handles.
- Chrome plated adjustable spray shower head.
- Chrome plated drain grated strainer.
- 1 1/4” P.V.C drain trap.
- All necessary fixing and accessories for connecting water mixer to main hot and cold water line and shower gratting with floor drain.

3.8 **Approved Manufacturers**

* **For Sanitary Fixtures**
  1. Rocca
  2. Velleroy and Boch
  3. Ideal Standard
  4. American Standard
  5. Twyfords
  6. Porcher

* **For Fittings and Mixers**
  1. Grohe
  2. Crane co.
  3. Twyfords
4. 
Ideal Standard
Or any approved Equivalent.

3.9 Approved Manufacturers

1. 4. Solar Water heater
The contractor shall supply and install solar hot water heater of capacity as indicated in drawings type vertical. The heater install on roof as indicated in the drawings completed with following item

• 3 Solar panel of size 190*90 cm insulated by polyethylene layer.
• Hot water storage tank of capacity 200 Liter and thickness of sheet metal 2mm painted in side by epoxy paint treated by oven. And insulated by 5Cm polyethylene and cover by galvanized sheet metal.
• Electrical heater coil 3000W.
• Plastic Water tank of capacity 1500 liter.
• Steel structure base for solar panel, hot water storage tank, cold water tank of height 2meter

Each heater shall be completed with all fitting such as valves, union, safety valve, non-return valve and all piping necessary for connection to city water, cold water and hot water electrical cable connected to heater coil with adjustable thermostat and electrical switch with indicated lamp

3.10 Pipes, Valves, and Fittings

3.10.1 General
Supply and install the pipe work as shown on the drawings. Pipe work shall be installed in a manner to allow for ease of air escape and system drainage. It shall be endeavored to obtain gravity. However, where conditions do not permit this, an automatic air vent shall be installed at all air pocket locations and a ½" drains gate valve shall be supplied and installed at low points and risen legs.

Drainage pipes inside the building shall be installed with a slope of not less than 1%. Drainage pipes outside the building shall have a slope of 1.5-2%. Before installing any pipe, it shall be internally cleaned of all dirt, sand, debris, etc.

Pipes shall be installed in a neat way with runs parallel and branching and change in direction at 90 degrees or at 45 degrees. Elbows shall be used for changes in directions; pipe bending shall be restored in extreme cases and only after the engineer’s written approval.

Sleeves shall be supplied and installed wherever pipes cross slabs, wall, partitions, etc.

Sleeves shall be cuts of pipes having an internal diameter of not less than 1 cm larger than the bare sleeved pipe or the insulated sleeved pipe depending on the particular situation. Floor sleeves shall protrude about 2 cm above the finished floor level. All gaps shall be plugged with a non-flowing plastic and water proof mastic paste.

All pipes shall be installed complete with:

• Metallic supports.
• Unions, flanges, coupling, elbow, tees, crosses, reducers, caps.
• Automatic air vents.
• Drain valves.
• All cutting, patching and making good of walls, slabs, partitions, etc... Due to fixing,
supporting and anchoring of pipes.
- All connections and fixing to equipment and accessories.

3.10.2 **Pipes and Fittings**

Potable water main between city mains and water collector in floor water cabinet shall be galvanized steel sch. 40, heavy weight. Fittings shall be of seamless pipe with same characteristics as pipe.

Domestic cold and hot water pipes shall be sch. 40. All pipe fittings (elbow, tees, crosses, unions, reducers, etc...) shall be galvanized forged steel of the same quality and weight as the pipes. Pipes and fittings shall be suitable for threaded connections.

All drainage pipes 11/4” in diameter and larger shall be UPVC -SN4 (Polyvinyl chloride) of approved quality UAP-Plast. All rain water pipes shall be UPVC-SN4 pipe. All fittings and accessories shall be of the same quality, and material of the pipe. All joints shall be rubber sealed stainless steel and plastic. Pipes and fittings shall be in accordance with latest PALESTINE standards.

3.11 **Valves**

**A. General**
Supply and install all valves as shown on the drawings and as required. All valves shall be designed for a working pressure of 150 p.s.i.

Gate, globe and check valves 2” and smaller shall have threaded ends, and 2 ½” and larger shall have flanged ends. All valves shall be of the same diameter as the pipe served, a union shall be used with all threaded gate, globe check and float valves.

**B. Gate Valves**
Gate valves 2” and smaller shall be bronze, screwed ends union bonnet, wedge disc type. Gate valves 2 ½ “ and larger, shall be cast iron, outside screw and yoke, flanged ends, bronze wedge disc faces and seats.

One gate valve shall be supplied and installed:
- At the supply and return from each equipment.
- At the suction and discharge of each pump.
- At the bottom of each riser and low points to be drained.
- In general, at all points shown on drawings and / or specified.

All valves in bathrooms and toilets shall be chrome plated recessed type where possible having the same handle as the fixture.

**C. Globe Valves**
Globe valves 2” and smaller, shall be all bronze, screwed ends, Union bonnet, renewable composite disc and seat.
Globe valves 21/2” and larger, shall be cast iron, outside screw and yoke, flanged ends, renewable composite disc and seat.

**D. Check Valves**
Check valves shall be used in the discharge line of pumps and at all points as shown on drawings. Check valves 2” and smaller shall be all bronze, screwed caps with check, renewable composite disc and seat.
Check valves 21/2” and larger shall be cast iron, flanged ends, bolted cap with lift check renewable composite disc and seat.

**E. Float Valves**
Float valves shall be all bronze, screwed ends, float operated. Float shall be all copper
and mounted at the end of a brass or copper rod, which actuated valve operation.

3.12 **Automatic Air Vents**
Automatic air vents of the ball type shall be installed at all high points in the piping network. A ½” lock shield valve shall be directly installed ahead of each A.A.V, and a ½” drain line shall be provided to discharge at a convenient point.

3.13 **Air Chambers**
Air chambers shall be provided on each individual water supply branch to each fixture having a flush valve. Air chamber shall be constructed of pipe and fittings, 12” long of the same size as supply piping.

3.14 **Vent Caps**
Supply and install vent caps on all waste and vent stacks at the levels shown on drawings. Each vent cap shall be of PVC construction as shown on drawings.

3.15 **Pipe Expansion Joints**
Supply and install where shown on drawings and as required, pipe expansion joints of the bellow type. All joints shall have flanged ends and stainless steel bellows suitable for a working pressure of 150 p.s.i.

3.16 **Unions and Flanges**
Unions and flanges shall be installed at all equipment inlets and outlets, at all valves inlets or outlets, on all pipe branches and in general every 10 meters of pipe run. Unions shall be used on the screwed pipes and shall be of the same quality and services. Flanges, suitable for welding shall be used on all welded pipes, and shall be all steel construction to ASTM or B.S. standards. Threaded flanges shall be on threaded pipes, when flanged valves and equipment are connected to the pipes, flanges shall be of the same quality and service as the pipe served, and shall conform to ASTM or B.S. standards.

3.17 **Pipe Insulation and Painting**
All hot water pipes shall be installed with 13 mm thick rubber foam insulation *Armoflex*. Pipes running under tiles shall have additional cover of cement-sand mortar with no lime. All piping, in trench, partition, below tiles, or underground shall receive two coats of red primer and then wrapped with one layer of self adhesive PVC tape, specially made for pipe protection. All expose pipes, fittings, unions, flanges, valves, hangers and supports shall receive two coats of red lead primer and two coats of finishing paint. All insulated metal surfaces exposed to view shall receive two coats of base paint before the application of the insulation and two coats of finishing paint over the insulation, if the insulation is exposed to view. The surface, requiring prime painting, shall be cleaned thoroughly of all rust, loose scale, oil, grease and dirt. Use wire brushes and solution for this purpose. No painting shall be done on damp surfaces, shop coated surfaces shall be cleaned thoroughly and retouched where necessary. The paint shall be evenly spread and well brushed out so that there shall be no drops, runs or sagging. Care shall be taken not to paint controls, label plates and nameplates. All items that have rusted or corroded in storage or in place shall be re-cleaned or repaired upon request of the Engineer.

3.18 **Floor Drains**
The contractor shall supply and install all floor drains as shown on drawings. Each floor drain shall be UPVC 4” / 4” and 4” / 2” complete with copper chrome plated 15*15 cm cover connected into the drain body. All floor drains shall have one removable chrome plated closed cover over their strainer. UPVC 1 ½” and 2” drain pipes for wash basin and sink shall be connected to floor drain. Approved manufacturer (Holliot).
3.19 **Roof Drain**
Each roof drain shall be UPVC pipe constructed with no trap (RADI) having an integral flange and wire dome type strainer fixed by screwing into the drain body. Rain drain shall be installed as shown on drawings.

3.20 **Clean - Out Opening**
Clean out boxes shall be approved UPVC with back and/or side inlets and to diameters as required and as shown on the drawings or specification. They shall be provided with an air tight sealant, cover of stainless steel, bolted down with counter sunk screwed. They shall be bedded on and surrounded with concrete mix of 15 cm thick.

3.21 **Maintenance and Guarantee**
The contractor shall be responsible for the maintenance of all system at his expense for duration of one year starting from the date of issue of the completion certificate. Maintenance shall include replacement of parts or whole equipment that shown any manufacturing or installation defects during operation.

The contractor shall also guarantee all systems from any manufacturing or installation defects for a period of one year from the date of issue of the completion certificate.

3.22 **Soil and waste pipes**
1. Soil, waste and vent pipe shall be of UPVC-SN4 pipe (Polyvinyl chloride) type U.A.P-PLAST of size 32mm till 150mm.
2. All fitting for soil and waste pipes such as Elbow, T, Floor traps, ...etc of same UPVC material. Type HOLLIOIOT
3. Connection between pipe and pipe fitting done by socket and spigot with rapper sealed
4. Connect sanitary fittings and floor drains to manholes by means of soil and waste pipe.
5. Soil and waste pipe shall be of the same diameter as the outlet to the sanitary fitting or floor drain. Reducers shall not be used except where they are required at inlets to floor drain and vent pipes.
6. Provide vent pipes to dimensions and at locations shown on drawing or as requested by the Engineer.
7. Vent pipes shall be carried up to 100 cm above roof slab and shall be provided with approved patent vent head preventing entry of animals or objects and facilitating good ventilation of stacks.
8. Where vent pipes penetrate roof slabs, sleeve must be provided above it, and roof finishes and water proofing must be carried up around the pipe and covered with sleeves to prevent water penetration, all to the approval of Engineer.
9. For testing soil and waste stack the system shall be subjected to water test prior to being covered and also tested for water tightness after back filling.
10. On any section of pipe under test the head of water applied shall not be less than 3 meter and not more than 6 meter. Test shall be maintained for 20 minutes and any defect shall be rectified and the test reapplied to the complete satisfaction of the engineer.
11. Sewage pipes between manholes shall be done by UPVC-SNB red color pipe.

3.23 **Approved Manufacturers**

<table>
<thead>
<tr>
<th>Item</th>
<th>Appr. Manufacture</th>
</tr>
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<tbody>
<tr>
<td>Gate Valve</td>
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<tr>
<td>Check valve</td>
<td>York</td>
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<tr>
<td>Ball valve</td>
<td>Giacomeni</td>
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<tr>
<td>Strainer</td>
<td>Ary (Germany)</td>
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<tr>
<td>Safety valve</td>
<td>Braukmen</td>
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<tr>
<td>Pressure reducing valve</td>
<td>Califi</td>
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3.24 Below Ground Drainage Installations

3.24.1 General Description
The work under this section of the specifications shall include all underground drainage pipe work complete with gullies, traps, cleanouts, manholes, and all accessories, as shown on the drawings.

Below ground drainage pipework shall mean all pipework located under ground floor slab inside buildings and all external pipe network.

3.24.2 Pipework - General
The pipes and fittings shall be unplasticised polyvinyl chloride UPVC-SN8.

Pipe size 110 mm. and 160 mm. shall conform to BS 4660,

Pipes and fittings shall be manufactured with polyproplene seal retaining caps.

3.24.3 Pipework - Installations

1. Excavation

All excavations shall be formed with vertical sides and of not greater dimensions than stated in this specification, with allowance for timbering, shuttering or other necessary temporary work.

Excavation beyond these dimensions for any convenience of the contractor will not be permitted and should any excavation exceed the width or depth stated, to the detriment of the support or foundation of any of the works, the contractor shall refill such extra with C7.5P concrete or as directed at his own cost.

The sides of trenches, manholes and other excavations shall be adequately supported at all times.

Any material excavated in forming pipe drains shall, if found unsuitable, be run to spoil and replaced with suitable approved material. All suitable excavated material shall be used as backfill except in French drains.

Timber, sheeting, piling, struts, wallings and bracings may only be left in the excavations if so directed.

The formations of all excavations are to be cut and trimmed to the exact lines, levels and depths as shown on the drawings, or to such other lines, levels or depths as directed.

Where a concrete or granular bed or surround is required to the pipeline, manhole etc., the excavation shall be taken out to the overall dimensions of the bed or surround. The sides of the trench shall be vertical with no undercutting.

Where pipelines are to be laid pipe on granular bed the concrete fill to over-excavation shall be shuttered to provide the trench width specified, up to 300mm above the barrel of the pipe.
Where pipes are to be laid at or below existing ground level under fill, and there is less than 1.2m of existing ground above the pipe crown, the fill shall be completed to a depth of 1.2m above the crown of the pipe, and the trenches excavated in fill material for such pipelines and associated structures.

Soft spots shall be removed from the bottom of the trenches and other excavations, which shall then be refilled to formation level with the same material and compaction as the permanent work, which is to rest on their formation. Any void which results from over excavations below formation level shall refilled in the same manner.

All excavations shall be cleared of water both by day and by night, and shall be shaped to prevent any accumulation of water either in or adjoining the excavation or the spoil therefrom.

Sumps shall be constructed and maintained clear of all excavations for permanent works, so that water at all times must be kept below any permanent works in the course of construction.

Ground water and water arising from construction shall be maintained away and not permitted to enter the permanent drainage systems.

Excavated materials which is suitable for use as a backfill shall be adequately protected to maintain its suitability for reuse.

Excavated materials or any other materials shall be placed at as safe distance from the excavation and shall not be placed closer than a horizontal distance equal to the depth of the excavation, unless suitable working and safe arrangements are made.

2. Supports for excavations

All excavations shall be supported and secured to ensure the proper execution of the works and to prevent any settlement of the adjoining ground or structures thereon. Systems of timbering using poling boards, runner or steel trench sheeting shall be used according to the ground conditions and shall be designed to prevent loss of ground during excavation and to ensure that backfilling can be carried out in accordance with the requirements, leaving no voids.

3. Trench widths (excluding land drains)

From the bottom of the trench to a level 300mm above the crown of the pipe, trench widths shall not be less than the minimum nor greater than the maximum figures shown in the table below.

<table>
<thead>
<tr>
<th>Pipe Nominal Diameter (mm)</th>
<th>Minimum Trench Width (mm)</th>
<th>Maximum Trench Width (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
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<td>525</td>
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<td>1200</td>
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<tr>
<td>600</td>
<td>1240</td>
<td>1350</td>
</tr>
</tbody>
</table>
Irregularities and overbreak shall, unless otherwise agreed prior to the commencement of permanent work, be made good to the correct dimensions with concrete as specified.

4. Drainage Pipe Laying

A. General

The installation of pipework shall be carried out in accordance with the requirements and recommendations of BS. 8301 unless more stringent requirements are stated in this specifications.

Before the commencement of the pipe layouts, the position and level of the drains or sewer to which it is proposed to make a connection shall be confirmed, if necessary by excavation.

B. Levels

All pipes shall be laid truly straight lines in directions and gradient between manholes, rodching eyes access chambers, etc. Bends shall be provided where shown on drawings and, in the event of any variations in the position of any manhole of the line of the sewer being considered necessary, the works shall be constructed as directed.

The allowance on given invert levels shall be ±5mm provided that the as laid gradient of the pipes runs between successive given invert levels shall not vary by more than 10% from that shown on drawings and provided that the relative level differences between pipes in an individual installation are maintained. The plan setting out shall be within ±5mm of the drawing dimensions.

Pipes shall be laid within the whole of the barrel of the pipes evenly and solidly supported by bedding materials, with shaped holes in the receive the socket. After making the joint, the bedding material shall be carefully packed around the joint to fill the void in the bed left joints. Hard packings shall not be used as permanent or temporary pipe supports; nor shall pipe spigots be permitted to bear on socket inverts in such a manner as to produce uneven pressure on the joints.

Notwithstanding the flexibility provided in the pipe joints, pipes must be securely positioned to prevent movement during and after the making of the joint.

The space between the end of the spigot and the shoulder of the socket of flexibly jointed pipes when jointed shall as recommended by the manufacturer.

Joints shall be made strictly in accordance with the manufacturer’s instructions, using the technical advisory services offered by the manufacturer for instructing the pipe jointers in the methods of assembling joins. Where manufacturer recommend the use of special jointing tackles, these shall be used for the assembly of all joints to pipes.

C. Protection

Immediately after flexibly jointed socket and spigot pipes have been tested, the gaps between barrels of the pipes and the internal face of the socket shall be sealed with puddle clay or other suitable flexible materials to prevent the ingress of the bedding and fill materials.
All pipe ends which are left open during the contract shall be temporarily fitted with propriety end caps as supplied by pipes manufacturer, where these are not available, expanding stoppers shall be used. Adequate precautions shall be taken to prevent floatation of the pipeline.

Pipes shall not be burried at less than 600 mm. below finished grade for protection against mechanical damage.

Pipes shall not be run closer than 1 m. to building bearing walls and footings for protection against building settlement.

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 the entire length.

D. Drainage under building
Where drain trenches are to be excavated beneath foundations or below the level of adjacent foundations, the sides of the excavation shall be supported by such substantial planking and strutting as steel trench sheeting driven plumb in advance of the excavation proceeding. The trench sheeting shall be carefully withdrawn after compaction of the backfill material so as to cause the minimum disturbance to the backfill and adjacent ground.

Where the top of a pipe of equal to or less than 150mm diameter is within 300 mm of the underside of a concrete slab or footing, the pipe shall be bedded and surrounded in 200mm of canned concrete.

E. Drainage Through structure and manhole walls

There shall be two flexible joints at each point where the pipe lines is built into and supported by the structure or manhole/instructions, positioned at 150mm and 750mm from the face of the structure.

Where conditions necessitate that the drop would exceed 450 mm. at the maximum slope of 3%, a drop manhole shall be used, of detail as shown on the drawings.

All joints shall be inspected and an inspection of the lines as a whole shall show all pipes to be true to line and grade with full moon circle visible at the manholes.

If an inspection of the completed sewer or any part thereof shows any structures, pipes or joints which are defective, the defective work shall be replaced or repaired as directed.

3.25 Bedding and Laying Out of Drain Pipes - External

a. Immediately following the trench excavation, the pipes shall be laid and jointed on pipe bedding material.

b. The pipes shall be laid so that one is in contact with the bed throughout the length of its barrel. Bedding material being scribed away at each socket so that the socket does not hear on the bed. Pipes and channels shall be laid with the sockets leading up the
gradient. All drainage runs shall be commenced at the point of outfall or at a manhole.

3.26 **Bedding and Surround of Pipes - Generally**

After jointing the pipes, the bedding shall be brought up equally on both sides of the pipe, first to the level of the centre of the pipe line and then up to a height of 300 mm. above the top of the pipe barrel. This material shall be placed in layers not exceeding 150 mm. in thickness and shall be carefully compacted with wooden rammers.

3.27 **Backfilling of Trenches**

a. All backfilling shall, as far as practicable, be undertaken immediately after the specified operations preceding it have been completed.

c. The backfilling shall be undertaken only after completion of testing for such pipes as described herein. From 300 mm. above the barrel of the pipe up to the formation level of the road, the filling in the trench shall continue with selected approved material from excavations, in layers not exceeding 150 mm. in thick. Each such layer shall be solidly rammed before the next layer is added.

d. Where the drain does not run under a road, the backfill material shall be solidly rammed up to the existing ground level in the manner described above.

3.28 **Manholes - General**

Manholes shall be of precasted in place reinforced concrete construction and shall be of details shown on the drawings.

Manholes shall be constructed to the required depth. The manholes top shall have 600 x 600 mm clear opening and shall be shaped to accommodate a standard size manhole frame and cover.

Manhole floors shall be formed 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 side walls to the central channel.

3.29 **Benching and Inverts of Manholes**

The open channel in the bottom of the manholes shall be formed in the benching with half round of pipe. All side branches shall be connected to the main channel so that the discharge is in the direction of the flow in the main channel. The benching shall be concrete and shall rise vertically from the edge of the channel pipe to a height not less that the outgoing pipe and be sloped upwards from there to meet the wall of the manhole at a gradient of about 1 in 6. Rendering to benching shall be applied in a coat of cement mortar (1:1) to a final thickness of 20 mm trowelled to a smooth hard finish in accordance with BS. C.P. 301.

3.30 **Temporary Covers for Manholes**

Temporary covers shall be fitted and retained in position on all manholes from the time the top access is formed or the concrete cover slab installed, until the permanent cover is installed.

3.31 **Manhole Step Irons**

All manholes of depth greater than 1200 mm. shall be provided with galvanized steel irons complying with BS. 1247. They shall be staggered in two vertical runs at 300 mm. centers vertically and 225 mm horizontally.
The top iron shall be no more than 350 mm. below the underside of the manhole cover slab and the lowest no more than 300 mm. above the benching. Manhole cover frames shall be bedded in 1:3 sulphate resisting cement sand mortar.

3.32 Frames and Covers

The Contractor shall provide for each manhole cast iron frame and cover with a 600 mm diameter clear opening. The concrete masonry shall be neatly and accurately brought to the dimensions of the base of the frame. The frame shall be thoroughly embedded in mortar and frame and cover set level and to the proper grade.

All castings for frames and covers shall be of tough grey iron and shall be made accurately to dimensions and machined to provide even bearing surfaces. 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. All castings shall be carefully coated inside and outside with coal tar pitch varnish of approved quality.

All frames and covers shall comply with BS 497 of grads as indicated on the manholes schedules.

All manholes covers shall be provided with at least two keyways.

All covers and frames shall have clearly cast thereon the number of BS, the appropriate grade and the weight in kg.

3.33 Testing of Drains

General

Unless more stringent requirements are stated in this specification, all testing shall be carried out in accordance with CP 301.

a. The Contractor shall provide the necessary labour and equipment and include in his Tender for testing and work to the requirements and satisfaction of the Engineer and all relevant public authorities.

b. All drains and sewers shall be tested with air after being laid and jointed but before surround and backfilling is commenced to ensure that the jointing is satisfactory. The results of the test must be approved by the Engineer before connecting.

The air test shall be applied at a pressure equivalent to 100mm head of water shall be held for 5 minutes without further pumping; with loss not exceeding 25mm for satisfactory testing. Where gullies or other ground floor appliances are connected, a 50mm test should be applied with a maximum loss of 12mm over a 5 minute period.

A gauge in the form of a glass ‘U’ tube shall be provided and connected to the drain plug of the length of drain under test.

c. A further water test shall be carried out after the completion of the backfilling and manhole construction, the length tested being between manholes .Test shall be carried out in the manner described in the following paragraph.

d. To facilitate the general building programme, tests shall be made of sections as the work proceeds, such testing however will not absolve the Contractor from his liability for any subsequent or final testing.

e. Any defects that become apparent during these tests of any part or parts of the
installation shall be rectified at the Contractor's expense and the part, or parts, retested to the satisfaction of the Engineer and the relevant public authorities.

f. For a water test, the drain lines shall be subjected to test pressure of 2.5m. Head of water at the highest point of the section under test. Allowance should be made for added water until absorption has ceased, after which the test proper should be commenced and the water level be maintained for a minimum of 30 minutes without the addition of further water.

The same diameter as the drain at end shall be fitted temporarily, in the socket of the last pipe laid the joints being made water tight. The length under test shall be fitted with water. The length under test shall be filled with water and after allowing for 2 hours absorption and topping up. The water level in the pipe shall be observed for 30 minutes. The test shall be regarded as satisfactory if the loss of water does not exceed:

<table>
<thead>
<tr>
<th>Pipe Diameter (mm)</th>
<th>Water Loss (liter per meter run)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>.05</td>
</tr>
<tr>
<td>150</td>
<td>.08</td>
</tr>
<tr>
<td>225</td>
<td>.12</td>
</tr>
<tr>
<td>300</td>
<td>.15</td>
</tr>
</tbody>
</table>

g. Test for straightens and obstruction shall be made to the Engineer's satisfaction and in accordance with the requirements of B.S.C.P. 301, Building Drainage.

h. The whole of the installation shall be left clean and free from debris.

i. The Contractor shall keep a record of the tests carried out on the drainage installation throughout the Contract, recording date of test, by whom tested and the result, one copy of the records shall be sent to the Engineer on completion of the Contract.

3.34 Testing of Manholes

Manholes shall be subjected to a hydraulic test. Pipe stoppers shall be inserted into all pipe ends and the manhole filled with water to a height of 1500 mm above the benching invert. This water shall stand for five minutes for absorption to take place and then be topped up as necessary. The water shall then remain at this level for a further two hours to satisfy the test. If the water level falls, then all defects shall be made good to the satisfaction of the Engineer, and the test shall be repeated as many times as may be necessary until the manhole is satisfactory.

3.35 Local Regulations

All works shall be carried out to comply with the current local public health regulations, the latest BS 5572/BS 8301 and current local by-laws and shall be to the entire satisfaction of the Engineer.

3.36 Solar Water heater

The contractor shall supply and install solar hot water heater of capacity as indicated in drawings type vertical. The heater install on roof as indicated in the drawings completed with following item

- 3 Solar panel of size 190*90 cm insulated by polyethylene layer.
- Hot water storage tank of capacity 200 Liter and thickness of sheet metal 2 mm, painted in side by epoxy paint treated by oven. And insulated by 5Cm polyethylene and cover by galvanized sheet metal.
- Electrical heater coil 3000W.
- Plastic Water tank of capacity 1500 liter.
- Steel structure base for solar panel, hot water storage tank, cold water tank of height
2meter

- Each heater shall be completed with all fitting such as valves, union, safety valve, non-return valve and all piping necessary for connection to city water, cold water and hot water electrical cable connected to heater coil with adjustable thermostat and electrical switch with indicated lamp.